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LANDING CRAFT UTILITY AS A FORCE MULTIPLIER IN THE LITTORALS

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Abstract
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As defense budgets tighten with each passing year, the Navy is presently building or planning to build a small number of large and high-cost ships. The manufacturing cost and declining numbers of these vessels essentially makes every one of them a "capital ship." In order to protect them from danger during future littoral missions, this paper will forward the proposal that a small amphibious landing craft – the Landing Craft Utility (LCU) – can be used as a more cost-effective alternative to close exposure to enemy attack. This paper will briefly trace the history of modern landing craft and will look at non-traditional missions for them. It will explore the range of operations currently required of Navy landing craft and examine ways to make more effective use of scarce assets in the areas the Navy/Marine Corps team is most likely to conduct future operations – the littorals.

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Preface

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This paper will briefly trace the history of modern landing craft and will look at non-traditional missions for such craft. It will explore the range of operations currently required of Navy landing craft and examine ways to make more effective use of scarce assets in the areas the Navy/Marine Corps team is most likely to conduct future operations – the littorals.

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force multiplier -- A capability that, when added to and employed by a combat force, significantly increases the combat potential of that force and thus enhances the probability of successful mission accomplishment.

-- *Joint Pub 1-02, DOD Dictionary of Military and Associated Terms*

INTRODUCTION

With the tightening of defense budgets since the breakup of the former Soviet Union, the Navy is currently building only four classes of surface ships with an additional plan for only one new class of ship. Ships currently in production include the Arleigh Burke-class (DDG-51) AEGIS destroyer, San Antonio-class Landing Platform Dock amphibious ship (LPD-17), one Amphibious Assault Ship (LHD), and one Aircraft Carrier (CVN). The 21st Century Zumwalt-class destroyer (DD21) is planned to replace the aging Spruance-class destroyers and Perry-class frigates. San Antonio-class LPDs are planned to replace several older classes of amphibious ships.

One decision made during the 1997 Quadrennial Defense Review regarding surface combatant[1] shipbuilding limited production of new ships while also reducing the overall size of the surface combatant fleet to 108 active ships and 8 ships in the Naval Reserve Fleet. The more capable new construction ships are planned to replace older ships as they are decommissioned, and are intended as such to maintain surface combatant ship numbers at 116 total ships.[2]

[1] William S. Cohen, *Report of the Quadrennial Defense Review* (Washington, DC: GPO, 1997), 46, 58-60. Cited hereafter as *Report of the Quadrennial Defense Review.* Combatant ships are considered as cruisers, destroyers, and frigates. Naval force categories are defined as aircraft carriers, ballistic missile submarines, attack submarines, surface combatants, amphibious ships, mine warfare ships, and logistics/support force ships.
[2] *Report of the Quadrennial Defense Review*, 29.

The manufacturing cost and declining numbers of these ships essentially makes every one of them a "capital ship." A single Burke-class destroyer costs in excess of one billion dollars, with ten more remaining to be built on the current order that runs through Fiscal Year (FY) 2005.[3] The projected new Zumwalt-class destroyers will be built in two different shipyards and are projected to cost $750 million per copy by the time the fifth ship is delivered from each shipyard.[4] Ultimately, the Zumwalt-class destroyer appears to be slightly cheaper than the Burke-class, though the cost of the first five ships may likely exceed this estimate by a significant margin.

In order to keep these high cost ships from harm during future missions, this paper will develop a proposal outlining the use of smaller landing craft as a more cost-effective alternative to use of such ships in a high-threat coastal environment. It will also show that landing craft can be used as a force multiplier – that is, something that gives additional capability and flexibility to a force commander and increases the overall effect of the force. This function as a force multiplier would serve to ease the burden of the high risk and often mundane operations that high cost ships are currently conducting with increasing regularity close to shore.

To achieve this end, this paper will briefly examine the history of the U.S. Navy's involvement in both riverine and amphibious warfare, and will then trace the lineage of the modern landing craft from the Higgins Boats of World War II to the planned replacement for the Landing Craft Utility – the LCU(R). It will then follow the development of the Navy's operational policies since the fall of the Soviet Union, explore

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[3] William S. Cohen, *Report of the Secretary of Defense to the President and Congress 2000* (Washington, DC: GPO, 2000), 58.
[4] "Acquisition Strategy," DD-21 Homepage, URL: <http://sc21.crane.navy.mil/dd21/acquisition/acq-strat.htm>, accessed 13 January 2001.

the range of operations currently required of Navy landing craft, and examine some of the Navy's non-traditional missions. Finally, it will compare the LCU to the Landing Craft Air Cushion (LCAC) and evaluate their capabilities to complete a wide variety of anticipated future areas of operations such as a mobile strike base for raiding parties, cryptography and signals intelligence (SIGINT) collection platform, and new riverine possibilities.

The final comparisons will look at exactly how landing craft can be used as a force multiplier in the future, and at the level of conflict in which they can safely operate. It will show that using landing craft in this fashion is a way to make more effective use of scarce assets in the area the Navy/Marine Corps team is most likely to conduct future operations – the littorals.

HISTORY OF NAVAL WARFARE ON INLAND AND COASTAL WATERS

The U.S. Navy's history of operations in inland water and riverine environments reaches back to its infancy as a service, starting with Benedict Arnold's campaign against the British on Lake Champlain in 1775-76. During the War of 1812, numerous battles were conducted on the Great Lakes and in Chesapeake Bay as the Navy moved into coastal operations. From 1835 to 1842, the 2nd Seminole War on the rivers and Everglades of Florida foreshadowed later developments and operations in a riverine environment. The Navy's involvement in the Mexican War consisted of port blockades and landing troops where they were needed, often going up rivers to do so. Since there was no opposing Mexican Navy, the Mexican War is often viewed as a land war only.[5]

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[5] Geoffrey S. Smith, "An Uncertain Passage," in *In Peace and War – Interpretations of American Naval History, 1775-1984,* 2d ed., ed. by Kenneth J. Hagan (Westport, CT: Greenwood Press, 1984), 91.

The Civil War saw the growth and evolution of coastal and riverine operations. The Union established coastal blockades of major Confederate ports and conducted numerous offensive operations into bays and harbors. The Federals also pursued extensive riverine operations on the Mississippi, Tennessee, and Cumberland Rivers. The joint venture between the Army and the Navy in the successful campaign against Vicksburg on the Mississippi is perhaps the best known of the Civil War riverine operations.

After the Civil War, riverine and coastal operations were few. The Navy eventually conducted river patrols on the Yangtze River in China in the 1920s and 30s. In 1935, the Marine Corps began to work on the problem of obtaining a landing craft capable of putting troops and equipment across the beach for amphibious operations. After years of testing, with several different boat designers and strenuous Navy objections to use their own designs, the Marine Corps settled on a 36-foot bow-ramp version of Andrew Higgins' *Eureka* boat.[6]

Higgins was a boat builder from New Orleans, and had originally designed the *Eureka* in 1926 as a workboat for oilmen, trappers, and others on the southern Mississippi River and the Gulf of Mexico. The "Higgins Boat," as it came to be called, led to the Navy Standard LCVP (landing craft, vehicle, personnel) which was the craft used throughout the Pacific for landing troops in amphibious operations. Higgins also designed a larger 50-foot craft which became the basis for the LCM (landing craft,

[6] Frank O. Hough and others, *Pearl Harbor to Guadalcanal*, vol. 1 of *The History of U.S. Marine Corps Operations in World War II*, (Washington, DC: GPO, 1958), 24-28. Cited hereafter as *Pearl Harbor to Guadalcanal*.

mechanized), which was used for landing heavy equipment and supplies.[7] Higgins' contributions to landing craft design were a key element in implementing World War II amphibious operations, and his design work is still seen in modern day LCM and LCU craft.

The only real instance of riverine operations in World War II occurred in Europe when amphibious landing craft were trucked inland to conduct an Army crossing of the Rhine River. In the Korean War, aside from amphibious landings, landing craft were used mainly for logistics transportation along the coast and up rivers to forward bases. LCMs were also occasionally used in a river gunboat fashion to deal with Korean forces attempting to infiltrate downriver and land behind United Nations lines. With these exceptions, riverine and coastal operations faded into memory until the United States became involved in the Vietnam conflict.

By that time, the Navy realized it had to re-learn how to conduct riverine and coastal warfare. The major forces employed in Vietnam were the Coastal Surveillance Force, the River Patrol Force, and the Mobile Riverine Force. The Coastal Surveillance Force consisted of destroyers, Fast Patrol Craft (PCF or "Swift" Boats), Patrol Air Cushion Vehicles (PACV), and Coast Guard cutters engaged in interdiction of arms and supplies from North Vietnam. The River Patrol Force operated on rivers in the southern portion of South Vietnam (IV Corps) fighting against the Viet Cong. They used River Patrol Boats (PBR), Minesweeping Boats (MSB), PACV, and LCM with Landing Ship Tanks (LST) as support ships.[8]

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[7] *Pearl Harbor to Guadalcanal*, 28-32.
[8] Department of the Navy, *The Navy in Vietnam,* (Washington, DC: GPO, 1968), 3-15.

The Mobile Riverine Force (MRF) was a joint operation by the Army and Navy that operated from self-propelled barracks ships and advanced shore bases in the Mekong Delta. With no other experience to work from, they based their operating concepts on the same strategies used during the Mississippi River campaigns of the Civil War, hoping for equal successes. The MRF mainly operated converted LCMs which were configured as Command and Communications Boats (CCB), Armored Troop Carriers (ATC or "Tango" boats), and Monitors. The Monitors were a throwback to the monitors of the Civil War era, and carried the largest guns of the MRF fleet – initially carrying 40mm anti-aircraft cannons, they later operated with 105mm howitzers – and thus acted as battleships of the river. The MRF also operated one specially built boat, the Assault Support Patrol Boat (ASPB). The ASPB operated like a destroyer for the MRF by screening and protecting the slower and more lightly armed Tango Boats.[9]

The Navy also conducted extensive logistic operations in I Corps area, immediately adjacent to the demilitarized zone. There, Navy LCU and LCM boats were the workhorses of this small landing craft fleet. They were modified to conduct minesweeping operations,[10] salvage and harbor clearance,[11] maintain clear waterways,[12] and haul heavy loads of high-explosive ammunition upriver in their open well decks.[13]

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[9] For more information of the specifics of the MRF boats and other patrol/landing craft see Appendix B.

[10] Edward J. Marolda, *By Sea, Air and Land – An Illustrated History of the U.S. Navy and the War in Southeast Asia* (Washington, DC: Naval Historical Center, 1994), 180. Cited hereafter as *By Sea, Air and Land*.

[11] Vice Admiral Edwin B. Hooper, USN (Ret.), *Mobility, Support, Endurance – The Story of Naval Operational Logistics in the Vietnam War, 1965-1968* (Washington, DC: Naval History Division, 1972), 203-204. Harbor Clearance Unit ONE was formed to provide combat salvage of sunken or damaged craft. Three LCUs were converted to Light Lift Craft (LLC) and capable of a 25-ton lift. Cited hereafter as *Mobility, Support, Endurance.*

[12] *Mobility, Support, Endurance*, 119. To keep the Cua Viet River open for navigation, an LCU was sent with a crane in its well deck to conduct dredging.

[13] *By Sea, Air and Land*, 193.

In addition, LCUs saw tactical use in combat. Most notably, LCUs were used during the Battle of Hue City to move Marines across the Perfume River after the bridges had been dropped.[14]

Vietnam provides the most recent examples of how to operate joint forces in a littoral and riverine environment. In the subsequent three decades much of this operational history has been forgotten. Operating in the littorals necessarily requires a naval power projection capability to provide the access needed to achieve mission goals. The origins of landing craft in the current inventory that will be used to project that power must be examined.

HISTORY OF CURRENT LANDING CRAFT

Modern landing craft today can draw their lineage and designs from the Higgins Boats. The current LCM-8 evolved from the slightly smaller LCM-3 of the late 1940s, and the LCM-6 of the 1950s and '60s, both of which were direct descendents from WW II landing craft. The first LCUs were simply re-designated Landing Craft Tank (LCT) Mark 5 that operated in the Pacific theater during WW II and again during the Korean War. The LCT Mark 6 was designed in mid-1944 and incorporated the stern ramp found in modern LCUs. Prior to 1958, LCTs and LCUs were classified as commissioned vessels and had an Ensign or Lieutenant Junior Grade serving as their Commanding Officer. Since that time, the LCU has been classified as a craft and given an enlisted "craftmaster" to guide and operate the vessel. There have been several different classes of LCUs. These include the LCU 1466-class (converted LCTs) and the collective

[14] Jack Shulimson and others, *The U.S. Marines in Vietnam – The Defining Year: 1968,* (Washington, DC: GPO, 1997), 198.

LCU-1600 class – the LCU-1610 class (delivered in 1959), the LCU-1627 class (delivered in 1968), and the LCU-1646 class (delivered in 1971).[15] A total of thirty-eight 1610, 1627, and 1646 class LCUs are still operated in Navy Assault Craft Units today.[16]

Though the LCAC can trace its history to the PACV of the Vietnam era, it actually evolved from five years of testing on two prototype craft. Dubbed JEFF A and JEFF B, they were produced respectively by Aerojet-General and Bell Aerospace. It was Bell's Amphibious Assault Landing Craft (JEFF B) that was awarded the production contract in February 1981.[17] Full production began in 1987 to provide a high-speed, over-the-horizon amphibious assault capability. The LCAC, like the LCU, also has an enlisted "craftmaster" in command of the five-man crew. There are currently 91 LCAC in the Navy inventory.[18]

LITTORALS: WHAT ARE THEY AND HOW DID WE GET HERE?

With the end of the Cold War, a shift occurred in U.S. Navy/U.S. Marine Corps thinking. The littoral areas have now become the focal point for both naval and joint forces in the 21st century.

Prior to the fall of the Soviet Union, the U.S. Navy operated under a doctrine called *The Maritime Strategy*. Designed to counter large communist forces in "blue water" operations far out to sea, this doctrine was suddenly left without an adversary in 1991 when the Soviet Union dissolved. The Navy and Marine Corps pondered exactly

[15] "ACU ONE History: Established 1947," URL: <www.acu1.navy.mil/HISTORY.HTM>, 1-4. Accessed 14 January 2001.
[16] *Jane's Fighting Ships, 1999-2000,* 102nd ed., Ed. by Captain Richard Sharpe, OBE, RN, (Frome and London, UK: Butler & Tanner Limited, 1999), 828. Cited hereafter as *Jane's Fighting Ships.*
[17] *Jane's Surface Skimmers – Hovercraft and Hydrofoils, 1984,* 17th ed., Ed. by Roy McLeavy, (London: Jane's Publishing Company Limited, 1984), 133-134, 146-147.
[18] *Jane's Fighting Ships*, 827.

how to deal with this void in the early 1990s. Following the Gulf War, the naval services developed a new strategic direction. Released in September 1992, the white paper *…From the Sea* moved away from the blue water open-ocean environment of *The Maritime Strategy* and toward the shore. Operating near the shore, in the littoral region, is where Navy would stake its new claim for future operations.[19]

…From the Sea gave rise to several follow-on doctrinal papers. *Forward…From the Sea* was published in 1994, re-emphasizing and clarifying the littoral strategy on which the services had settled.[20] In March 1997, the Navy published *Forward…From the Sea – The Navy Operational Concept*, also known as NOC. The NOC placed expeditionary operations and forward-presence at the forefront of the Navy's plan to execute its littoral strategy. The NOC also placed the Marine Corps' concept of *Operational Maneuver From the Sea* (OMFTS) on the table and announced the Navy's full partnership in "developing new amphibious warfare concepts and capabilities for…using the sea as a secure area from which to conduct ship-to-objective movement."[21] This was a landmark change from how amphibious operations had been conducted. Previously, landing forces were moved from ship-to-shore, a beachhead was established, and the forces pushed inland from the beachhead to the objective. OMFTS envisioned movement <u>directly from ship to the objective without an operational pause on the beach</u> to build up combat power.[22]

[19] Department of the Navy, *…From the Sea,* (Washington, DC: GPO, September 1992), 1-3. Jointly signed by the Secretary of the Navy, Chief of Naval Operations, and Commandant of the Marine Corps.
[20] Department of the Navy, *Forward…From the Sea*. (Washington, DC: GPO, November 1994), 1-7. Jointly signed by the Secretary of the Navy, Chief of Naval Operations, and Commandant of the Marine Corps. Cited hereafter as *Forward…From the Sea*.
[21] Chief of Naval Operations, *Forward…From the Sea – The Navy Operational Concept*, URL: <http://www.navy.mil/navpalib/policy/fromsea/ffseanoc.html>. Accessed 13 July 1999.
[22] U.S. Marine Corps, *Operational Maneuver from the Sea,* (Washington, DC: GPO, 4 January 1996), V-9 – V-11 and V-17 – V-22.

Two drawbacks of note exist in the concepts of OMFTS and *Ship-To-Objective Maneuver* (STOM): (1) their reliance on technologies and equipment that have not yet been developed and fielded, and (2) a seeming disregard for obstacles such as mine clearance and logistic support (fueling). Both are serious concerns. Worse is the apparent acceptance by both Navy and Marine Corps of these "concept" papers as doctrine. To accomplish the goals of OMFTS and STOM, the LCAC, MV-22 Osprey aircraft, and the Advanced Amphibious Assault Vehicle (AAAV) – the "Amphibious Triad" – are envisioned to move troops "from their ships directly to objectives ashore, uninterrupted by topography or hydrography."[23]

The problem with the foregoing assumptions is that only the LCAC is currently in a fully operational status. The MV-22 and AAAV have not yet been delivered for normal operations to fleet units.[24] The AAAV has only recently entered the Engineering and Development Phase, and will not reach full production and Initial Operational Capability (IOC) until FY 2006.[25] The MV-22, though approved as suitable for land-based operations in October 2000 after eight months of evaluation and testing, has recently had several setbacks and may not reach IOC as scheduled in 2001. It has not been approved for ship-based operations, full production, or multi-year procurement yet.[26] Though low

[23] U.S. Marine Corps, *Ship-to-Objective Maneuver*, (Washington, DC: GPO, 25 July 1997), II-4. Cited hereafter as STOM.
[24] Of note, the MV-22 has been advertised as being only "a year or two away from coming to the fleet" since 1985 when the author joined the Navy. Recent problems with the operational testing of the MV-22 have raised serious doubt as to its capabilities following several crashes and maintenance problems.
[25] Captain Steve A. Butler, USMC, "AAAV: Faster and Greater Power From the Sea," URL: <http://www.usmc.mil/marinelink/mcn2000.nsf/445312e1fd4fc5ea8525691500033829/0fe05db40f4ab3fb852569d10051e767?OpenDocumen t&Highlight=2,AAAV>, accessed 21 January 2001.
[26] "MV-22 Declared Effective, Suitable for Land-Based Ops," DefenseLINK News, URL: <http://www.defenselink.mil/news/Oct2000/b10132000_bt628-00.html>, accessed 20 January 2001.

rate production continues, concerns over reliability have triggered recent investigations that may push back IOC, though Full Operational Capability is expected in 2014.[27]

Of further concern is the reliance on the ability of specially modified mine-countermeasures LCACs, called MCAC, to conduct in-stride and assault breaching operations. In-stride breaching is designed to clear a path in sea mines laid offshore, while assault breaching clears a path in sea mines and land mines near the water's edge on an objective beach.[28] Until assault breaching operations, MV-22, and AAAV issues are resolved to allow OMFTS and STOM to become operational reality, the Navy and Marine Corps must continue to operate along the lines of established doctrine and strategy. Build up of combat power on a beachhead, followed by movement to the objective after an operational pause should continue to be used until that time.

A related matter is one of operational and tactical level doctrine, usually found in Navy Warfare Publications (NWP). A quick review of current NWPs reveals there is no clearly defined publication addressing littoral warfare. The closest existing topical publications are NWP 3-06M, *Doctrine for Navy/Marine Corps Joint Riverine Operations,* published in 1987, and NWP 3-10 (Revision A), *Naval Coastal Warfare,* published in 1998.[29] Unfortunately, NWP 3-06M in essence is really a re-numbered version of the old publication, NWP-13, *Doctrine for Navy/Marine Corps Joint Riverine Operations* – which was originally published in May 1978. Though modified three times between March 1980 and June 1984, it reads as if it were still meant for use in Vietnam-

[27] Captain Landon R. Hutchens, USMC, Marine Corps Division of Public Affairs, telephone interview by author, 25 January 2001.
[28] For a description of problems still being encountered in assault breaching, see "Stopped Short by Mines" by CAPT L.H. Rosenberg and LCDR R.T. Anderson, USN in the January 2001 issue of *Proceedings.*
[29] *Navy Warfare Electronic Library,* CD-ROM, Disc 3 of 9, (Newport, RI: Navy Warfare Development Command, Feb 2000), accessed 27 January 2001.

era riverine operations, even to the discussion of a mobile riverine force on the first page.[30] Published more recently, NWP 3-10 has a narrower focus on near-coast operations, harbor defense, and inshore operations. Written shortly after *Forward…From the Sea* was released, NWP 3-10 addresses the necessity of expeditionary coastal warfare. Though it lists a number of boats and craft to conduct coastal operations – such as Patrol Craft (PC), Mark V Special Operations Craft, and Boston Whalers – landing craft are not mentioned.[31] Reviewing the tasks and missions listed in NWP 3-10 it surely seems that, if available, landing craft could certainly perform requirements such as harbor defense and coastal security patrols, to name two specific tasks.

The most recent strategy doctrine modification, the 1998 Navy Posture Statement, again reaffirmed the littoral strategy. Entitled *Forward…From the Sea: Anytime, Anywhere*, it again placed forward-presence at the center of the Navy's role in meeting the requirements of the National Military Strategy and linked the service to the littoral strategy.[32] In 1998, the Marine Corps published another concept paper titled *Military Operations in a Riverine Environment* (MORE). This paper is directly in line with the tenets set forth in OMFTS and STOM, though it also suffers from the same shortcomings of reliance on technologies and equipment not yet fielded; it also disregards items like mine clearance and assault breaching. It does, however, envision that a majority of future conflicts will take place in the littorals where nearly 80 percent of the world's population lives. This new paper also correctly states that the littorals can qualify as a riverine

[30] Naval Warfare Publication (NWP) 3-06M, *Doctrine for Navy/Marine Corps Joint Riverine Operations*, (Washington, DC: Department of the Navy, April 1987), 1-1.
[31] Naval Warfare Publication (NWP) 3-10 (Rev A.), *Naval Coastal Warfare*, (Washington, DC: Department of the Navy, May 1998), 1-1 to 1-7, Appendix A.
[32] Edward Rhodes, "'…From the Sea' and Back Again: Naval Power in the Second American Century," *Naval War College Review*, LII, no.2, (Spring 1999): 45.

environment due to the inland water, rivers, and delta areas most often found near population centers.[33]

So, the Navy appears to have come full circle to operate in the same type of waters as that of the early Navy of the American Revolution. The Navy's dedication to operating forward in the littorals is certainly not open to question. But what is the most effective way to operate in the near land waters of future contingencies or conflicts? To examine this question the following must be reviewed:

1. the future missions to be accomplished in the littorals,
2. the types of operational goals to be accomplished,
3. the required capabilities of the vessels that will operate there, and
4. comparison of current landing craft in the Navy inventory for use in the littorals.

OPERATIONS AND MISSIONS

The stated future vision of warfare in *Forward…From the Sea* postulates five fundamental roles for the Navy: sea control and maritime supremacy, sea-based power projection to land, strategic deterrence, strategic sealift, and forward naval presence.[34] These roles are all connected to the current littoral strategy, though strategic deterrence and sealift are to a lesser degree.

In order to evaluate whether today's landing craft can function effectively in the future littoral environment, their current required operational capabilities (ROC) and

[33] U.S. Marine Corps, *Military Operations in the Riverine Environment* (Quantico, VA: GPO, 1 June 1998), 3-4.
[34] *Forward…From the Sea*, 6.

projected operating environment (POE) must be examined. ROC outlines what missions and capabilities a naval unit is able to accomplish. POE defines where, when, and under what conditions a unit will have to conduct operations. The mission areas and operational capabilities required of the LCU and LCAC can be found in a Navy publication titled *Projected Operational Environment (POE) and Required Operational Capabilities (ROC) for Naval Beach Groups and their Elements.*

The ROC/POE shows that both craft are expected to operate from amphibious shipping to conduct initial landing operations during the assault echelon (AE) phase. LCUs are further tasked to conduct the majority of the work in the assault follow-on echelon (AFOE) phase after combat troops have been put ashore. This often entails administrative, or general, unloading of the amphibious ships when items are brought ashore without concern for tactical usage. Both are capable of search and rescue (SAR) in combat and noncombat environments, as well as noncombatant evacuation operations (NEO), emergency/disaster assistance, and support of Special Forces raiding parties.[35]

Though both the LCU and LCAC have a basic self-defense capability, this is mainly oriented toward use of small arms against dismounted land troops and small watercraft. A later section will address possible initiatives to give landing craft more robust weaponry for defensive and offensive operations.

Both craft are required to operate during wartime, all-weather conditions and in limited chemical, biological, and radiological (CBR) environments. In addition to

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[35] Chief of Naval Operations, *Projected Operational Environment (POE) and Required Operational Capabilities (ROC) for Naval Beach Groups and their Elements* (OPNAV Instruction 3501.93C with Change 1), (Washington, DC: GPO, 27 May 1997), Encl (6), 1 – 2 and Encl (8), 1 – 2. Cited hereafter as ROC/POE for Naval Beach Groups.

describing wartime conditions, the instruction gives the following portrayal of peacetime surroundings:

> Peacetime forward operations in littoral areas are almost equally as demanding. These operations are frequently characterized by confined and congested water and airspace occupied by friends, adversaries and neutrals – making identification and coordination profoundly difficult. …surprise attack can be anticipated by submarines, coastal missiles, mines, sea-skimming cruise missiles and theater ballistic missiles.[36]

Clearly the littoral environment will not be a friendly one in war or peace. For a craft to survive and accomplish its mission, it must be highly flexible and capable of quickly adapting to new missions.

CAPABILITIES COMPARISON

Though the LCU and LCAC have very similar missions, they have very different capabilities and characteristics, as shown in Table 1. Their modes of operation and appearance are just as distinct. (See pages 47 and 48 in Appendix B for more characteristics and illustrations of both craft.)

	Crew	**Speed**	**Range**	**Payload**	**Displacement (Unloaded)**	**Mission Endurance**
LCU	11	11	**1200 miles**	**170 tons**	**200 tons**	**10 days**
LCAC	**5**	**40**	200 miles	60-75 tons	87 tons	12 hours

Table 1 – LCU/LCAC Comparison

Source: *Jane's Fighting Ships, 1999-2000, 102nd Edition*

[36] ROC/POE for Naval Beach Groups, Encl (6), 1.

The LCU is a displacement craft that is 134 feet long and 29 feet wide, while the LCAC is designed to operate mainly in a non-displacement mode as a hovercraft, but can operate in a displacement mode in an emergency. The LCAC is 87 feet long and 47 feet wide. Both craft are transported by amphibious ships to an intended area of operations, but due to their distinct dimensions fit differently in the well decks of the ships. Table 2 shows the maximum number of each type of landing craft that can be carried at one time in each ship's well deck.

SHIP TYPE	LCU	LCAC	Notes
LHA	4	1	
LHD	2	3	
LPD	1	1	
LSD-36	1	2	Mezzanine Deck installed (See note)
LSD-36	3	3	Mezzanine Deck removed (See note)
LSD-41	3	4	
LSD-49	1	2	Cargo Variant of LSD-41 class

Note: The LSD-36 Mezzanine Deck is a removable platform that splits the height of the well deck, and is used to store vehicles.

Table 2 – Amphibious Ship LCU/LCAC Carrying Capability

Source: *FMFRP 1-18, Amphibious Ships and Landing Craft Data Book*

Both crew size and crew duration can place limits on craft capabilities. The LCAC is held to a maximum "crew day" of 12 hours from the time the engines on the craft are started until it shuts down after the mission.[37] To conduct extended operations,

[37] Operational Handbook (OH) 1-9, *Employment of LCAC in Amphibious Operations*, (Quantico, VA: Marine Corps Combat Development Command, 1990), 1-7. Cited hereafter as OH 1-9.

an LCAC must return to its host ship to conduct a crew swap since any extra personnel carried in addition to the crew would be under the same crew day limits as the primary crew. The LCU is limited to a crew day of 16 hours from the time the crew awakes, but because the LCU is designed with living quarters an augment crew can be carried onboard to allow for 24-hour operations. Further, with its range and ability to make its own water with a reverse osmosis purification unit, the LCU can operate independently for up to ten days.

The ability to handle engineering problems and battle damage also sets the LCU apart from the LCAC. With its larger crew the LCU is configured to handle flooding, fire, and other casualties while continuing its mission. The LCU can also continue operations if it loses one of its two engines, or one of its two generators. Though the LCAC can still move if it suffers an engineering casualty to one of its four engines (two for forward propulsion and two for cushion lift), if it loses cushion it loses its speed advantage.

Additionally, an LCU can carry approximately 350 combat loaded troops to shore while an LCAC can only carry 24 troops in its normal configuration. To carry more troops the LCAC must load special personnel transport modules (PTM) in its well deck which protect the troops from the noise, dust, water spray, and winds developed by its gas turbine engines and propulsion air screws. With a maximum PTM configuration, 180 combat troops can be transported to shore.[38] Most LCAC detachments only bring one PTM on deployment, to be used among several craft. For example, the Whidbey Island-class Landing Ship Dock (LSD) was specifically designed to operate with LCACs, and

[38] *Jane's Fighting Ships*, 827-8.

normally takes four LCAC along for an operational deployment. Where the LCU is fairly self-contained with crew berthing, lounge, galley, and storage areas even when embarked in the well deck of an amphibious ship, the LCAC relies on its host ship for these necessities. The LCAC crew subsists wholly off the host ship, to include berthing, messing, office space, and spare parts stowage.

With regard to cargo, a current major weight limitation for the LCAC is its ability to carry heavy loads. The present LCAC cannot lift loads like the M1A1 tank without going into an "overload" condition in which it must sacrifice a significant amount of fuel in order to transport the 70-ton tank.[39] Additionally, if the temperature exceeds 100 degrees (F) with a Sea State 3 [40] or above, the LCAC cannot haul the M1A1, the M88 Tank Retriever, or the Combat Breaching Vehicle.[41]

The LCAC, however, does have a decided advantage in its ability to operate nearly anywhere. Studies have shown that the LCAC can cross over 70 % of the world's coastlines, while the LCU is limited to only 17 %. This is due to the LCAC's ability to ride above the waves while on cushion and transition from water to land nearly effortlessly, while the LCU has a limitation in landing on beaches that a have narrowly defined gradient, or slope, of the sea bottom near the water's edge. The LCAC does have limitations in the surf zone[42] where the height of the breaking surf near shore can

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[39] Pete Kusek, *LCU(X) Mission Area Analysis* (Alexandria, VA: Center for Naval Analyses, July 2000), 8. Cited hereafter as LCU(X) MAA.

[40] Sea State is defined several ways. Sea State 3 would encompass winds of 14 to 16 knots with waves of 3 to 5 feet. Though this seems negligible, it is significant for small landing craft. Representative charts and other information are shown in Appendix D.

[41] Office of the Chief of Naval Operations (Code N753), Memorandum for Program Executive Officer, Expeditionary Warfare, 7100, Ser N753/0U652021, subject: "Landing Craft, Utility, Replacement, (LCU(R)), MS "A," 14 November 2000, Encl. (2), 4. Encl (2) is the Mission Need Statement (MNS) for LCU(R). Cited hereafter as LCU(R) MNS.

[42] The Surf Zone is the area from where the first wave begins to break to the water's edge on the beach.

significantly lower its payload and speed. Though the LCAC is designed to operate in waves of up to 12 feet, to do so it must limit payload to 45 tons and use speeds of 20 knots or less.[43] There are many factors to be considered when choosing a beach for landing. For example, though the LCAC may land easily, troops or vehicles may not be able to exit the beach. This would cancel the supposed advantage of being able to land on more beaches.

Displacement craft such as the LCU also have limits described by the Modified Surf Index (MSI), a figure which takes into account such parameters as significant breaker height, period between breakers, type of breaker, littoral current, relative wind direction and speed, and secondary wave height. All these factors yield a number that provides a relative measure of the difficulty of conditions to be encountered in the surf zone, and whether or not operations for a given displacement craft are feasible. As an example, the maximum operational MSI for a flat powered causeway (barge) section is 6, while an LCU's maximum wartime MSI is 12.[44] Current instructions at Assault Craft Unit ONE in San Diego, California limit LCU operations during training evolutions to an MSI of 6.[45]

Though it may appear that the LCU and LCAC are diametrically opposed in their capabilities, they complement each other in their current uses in the amphibious fleet. The speed advantage the LCAC enjoys makes it a perfect choice for Over-the-Horizon (OTH) assaults or raids and has earned it the role as the current choice for D-Day type

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[43] Commander Naval Surface Forces, Atlantic Fleet/Commander Naval Surface Forces, Pacific Fleet (COMNAVSURFLANT/COMNAVSURFPAC), *Joint Surf Manual*, (Instruction 3840.1B with Change 1), Norfolk, VA/San Diego, CA: COMNAVSURFLANT/COMNAVSURFPAC, 1987, 57. Cited hereafter as *Joint Surf Manual*.
[44] *Joint Surf Manual*, 50-55. Excerpts explaining how MSI is calculated are provided in Appendix C.
[45] Assault Craft Unit ONE, *Standard Operating Procedures (SOP) for Landing Craft Utility (LCU)*, (Instruction 3120.4D), San Diego, CA: ACU ONE, 27 January 1999.

assault echelon operations.[46,47] The LCU, because of its heavy-lift capability, is designated for operations after D-Day. A task force commander may, however, choose to use the LCU in the assault echelon against a defended beach due to its ability to better survive battle damage.

NON-STANDARD OPERATIONS

With every deployment, LCUs have conducted a variety of new tasks in addition to their required missions and capabilities. While in the Arabian Gulf in 1999, an LCU was dispatched independently to conduct Maritime Interception Operations (MIO) in support of United Nations Security Council Resolutions prohibiting oil and other goods from going into or out of Iraq. The LCU, with a boarding team from its host ship, conducted queries, boarded, and searched several vessels in an area into which its host ship could not venture due to shallow water.[48] This is but one contemporary example of how an LCU can fill a mission requirement for a larger ship.

From October to November 1999, the USS PELELIU (LHA-5) Amphibious Ready Group (ARG) and its two LCUs participated with United Nations Peacekeeping Forces in East Timor while returning from deployment. Both LCUs operated independently on a frequent basis, conducting the transfer of cargo, personnel, and equipment from ship-to-shore and between port facilities and beach areas. During a 36-

[46] Commander Thomas Nicolas, USN. Expeditionary Warfare (N753E) Staff Officer, Department of the Navy, Office of the Chief of Naval Operations, interview by author, 17 November 2000.
[47] Doctrine in Joint Publication 3-02, *Joint Doctrine for Amphibious Operations*, states that though assault operations against an enemy may be conducted against a hostile shore, naval and air superiority are expected to be attained prior to conducting the operation.
[48] Assault Craft Unit ONE letter excerpts to Director of Navy History (Attn: N09BH), subject: "1999 COMMAND HISTORY," 23 January 2000, Encl (4) and (5). Cited hereafter as ACU ONE 1999 Command History.

hour trip along the coast between two ports, PELELIU transported cargo and supplies in the well deck space the LCUs normally occupied, while the LCUs hauled their own cargo.[49] Clearly, LCACs would not have been able to conduct such a mission due to their limitation to 12 hours of operation, and the unavailability of the well deck for crew swap and refueling. In a mission status report, the Amphibious Squadron ONE Commander stated that "LCU's are the Main Battery" for East Timor operations.[50]

In early February 2000, mission flexibility was shown when one LCU was dispatched from San Diego on short notice and assisted the U.S. Coast Guard and National Transportation and Safety Board in recovery efforts and salvage of aircraft parts from Alaska Airlines Flight #261. This plane crashed off the California coast when it experienced problems with its horizontal stabilizer on 31 January 2000.[51] The LCU operated independently near the crash site for several days at a time while working from a contingency base of operations established at Port Hueneme, California. On 9 December 1999, a similar event occurred when a Marine helicopter crashed while attempting to land on the deck of a Military Sealift Command oiler during training operations near San Diego.[52] One LCU conducting independent training operations immediately took part in the search and rescue operation.[53]

As an interesting side note, the U.S. Army also operates many conventional landing craft, including 90 LCM-8, 13 LCU-1600 class, and 35 LCU-2000. The Army

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[49] ACU ONE 1999 Command History, Encl (4) and (5).
[50] Commander W. Curtis Hammill, USN, Commanding Officer, Assault Craft Unit ONE, e-mail to author, subject: "LCU of the Future for the Navy-Marine Corps Team," August 2000, PowerPoint slide 3.
[51] "Families of crash victims wait as word of hope fades," *CNN.com*, URL: <www.cnn.com/2000/US/02/02/alaska.airlines.02/index.html>. Accessed 25 February 2001.
[52] "Search still on for lost Marines," *CNN.com*, URL: <www.cnn.com/1999/12/10/helicopter.crash.01/index.html>. Accessed on 25 February 2001.
[53] Assault Craft Unit ONE draft Letter to Director, Naval Historical Center, 5750, subject: "2000 COMMAND HISTORY," Undated, received 17 Jan 2001. Encl. (4).

LCM-8 and LCU-1600 craft are theoretically capable of embarking in Navy amphibious ships, but the LCU-2000 is too large to fit in the well decks of Navy ships. The LCU-2000 was built specifically for Army use and has a lift capability of 350 tons (five M1A1 tanks), significantly more than the LCU-1600 lift of 170 tons, and is capable of self-deployment with a range of 4500 miles.[54] Army watercraft are tasked to perform post-assault resupply missions, conduct Army or Joint Logistics over the Shore (LOTS/JLOTS) operations, ship-to-shore harbor transfer, and harbor utility functions. Additionally, they are charged with support of naval amphibious operations.[55] If Army watercraft are available in a coastal, riverine, or amphibious joint operations area, they could be expected to perform the same tasks as Navy displacement landing craft.

In the littorals of the future, joint naval operations could take the form of amphibious assault, coastal warfare, logistic support, river patrols, and riverine operations as well as the non-standard operations listed above. The next section will explore future missions, craft types, and capabilities to determine if landing craft are suitable to conduct missions close to shore that are normally tasked to surface ships – and can thus perform as force multipliers for task force commanders.

LANDING CRAFT AS A FUTURE FORCE MULTIPLIER

The Navy's operational landing craft of the future for littoral operations will be the LCU(R) and the Enhanced LCAC. With a few minor exceptions, LCU(R) will be able to function and perform missions similar to the present LCU; it thus virtually mirrors

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[54] *Jane's Fighting Ships*, 828.
[55] U.S. Army Combined Arms Support Command, *Army Watercraft Master Plan.* URL: <http://www.cascom.lee.army.mil/transportation/ArmyWatercraftPlan.htm>, accessed 10 January 2001.

the current LCU's capabilities with some operational enhancements.[56] The heavy lift payload of LCU(R) is anticipated to increase to allow for transport of three M1A1 tanks, vice the limit of two for the current LCU. The LCU(R) will be designed to take up the same amount of space in the well deck of amphibious ship as the current LCU, and will also be compatible with cargo handling systems of current and future MPF ships as well as various sealift ships. Extended operations of up to 10 days will be required, as will command and control systems that allow for full connectivity with amphibious task force units and MPF platforms. The LCU(R) can be expected to make maximum use of automation and technological advances to allow for a decrease in manning.[57] Though a smaller crew could mean a shorter operational cycle, an augment crew could be used when the need arises to allow for extended independent operations.

The recently approved Enhanced LCAC program will conduct a Service Life Extension Program (SLEP) process on the entire fleet of 91 LCACs. The original goal was simply to extend the useful service life of these craft. However, the SLEP process will reset the hull life of each LCAC by replacement of the aluminum hull plating and give an additional 20 years of service life upon SLEP completion; this will be longer than the originally intended 10-year extension. Mechanical systems will be refurbished and a new fuel system with increased capacity will be installed. The craft will also receive a "deep skirt"[58] which increases vertical clearance over obstacles by two feet and improves its performance at sea so it can attain higher speeds in higher sea states.

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[56] See Appendix B for more characteristics of both the LCU and LCAC.
[57] LCU(R) MNS, 2-4.
[58] The skirt of an LCAC is the rubber sheath, which holds the air cushion the craft rides on.

Of greater note, each LCAC will receive improved engines that will provide a 20 percent increase in power output. This will allow the LCAC to get "over the hump"[59] with a heavy load, such as a M1A1 tank, in Sea State 3 on a 100 percent humidity day. Finally, the communication/navigation system will be upgraded with an inertial navigation global positioning system (GPS), a Windows-based computer navigation system, an amphibious craft transponder tracking system, and improved radios.[60]

Both LCU(R) and Enhanced LCAC will rely on speed, maneuver, and support from other platforms, such as ships or aircraft, to survive attacks from sea, air, and land threats in the littorals. Both are able to mount machine guns and similar weapons for self-defense, but due to its operating characteristics the LCU could also be fitted for a number of other weapons. Weapons that could be employed on LCU(R) include Stinger missiles for air defense, 25 mm cannon for surface craft defense, and 81 mm naval mortars[61] for engaging both surface craft and shore emplacements. This would arm them similarly to the Swift boats of Vietnam. Augmentation by Marines and their weapons systems operating from the well deck could provide increased firepower and versatility.

From the force multiplier standpoint, the idea of using landing craft in the littorals can be compared to the "Streetfighter" concept, recently renamed the "Contested Littoral Delivery System." Briefly stated, Streetfighter is a family of systems designed to assure

[59] OH 1-9, 1-1 to 1-4. As an LCAC accelerates over water it reaches a critical speed in the 18-20 knot range. While hovering, an LCAC creates a depression in the water equal to its weight. When the LCAC moves the depression moves with it. At about 18 knots the LCAC begins to "fly out" of the depression, or go "over the hump." By 21 knots the depression is gone, and less power is required to maintain speed.
[60] Dave Vickers, Expeditionary Warfare (N753L) Program Analyst, Department of the Navy, Office of the Chief of Naval Operations, telephone interview by author, 18 December 2000.
[61] A naval mortar is different from mortars used in land combat in that it does not fire automatically, but is fired by trigger and is capable of depression to a firing elevation of zero.

access in the littorals of the future.[62] Access will be required in all future situations, whether they be presence operations or contested landings ashore. Streetfighter envisions three requirements for power projection forces of the future: a network to link the systems and platforms, robotics, and new types of small surface ships – also called "Streetfighters." These new surface craft will be small, fairly stealthy, and have a modular system that will enable them to adapt to different missions by changing weapons and sensor system modules.[63] Thus, Streetfighter ships could act like destroyers, cruisers, or even amphibious ships with the proper modular packages installed.

When the Streetfighter concept becomes operational, hopefully about 15 years from now, the idea of using landing craft in the littorals for a number of missions may change significantly.[64] But until that time, for sustained operations the LCU has a distinct advantage over the LCAC in its ability to conduct extended independent operations. This will be especially true for future littoral, coastal, or riverine tasks.

FUTURE OPERATING ENVIRONMENT

The littoral operating environment of the future will encompass coastal waters, bays, harbors, and rivers and their associated deltas. According to the tenets of OMFTS, the coastal environment can be assumed to run from the shoreline to approximately 25 miles out to sea, the generally stated starting point for over-the-horizon (OTH) operations. The other areas are self-explanatory.

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[62] For more on "Streetfighter," see "Rebalancing the Fleet" by Vice Admiral A.K. Cebrowski, USN and Captain Wayne P. Hughes Jr. in U.S. Naval Institute *Proceedings*, November 1999, 31-34.
[63] Commander Al Elkins, USN, Naval Warfare Development Center Staff Officer, Department of the Navy, telephone interview by author, 4 January 2001.
[64] Commander Al Elkins, USN, Naval Warfare Development Center Staff Officer, Department of the Navy, e-mail to the author, 3 April 2001.

The threats to be encountered within this littoral environment in a worst case scenario will consist of a layered, integrated defense. Starting at the outer edge, 25 miles offshore or greater, submarines will operate freely. Though landing craft have no anti-submarine detection or weapons capabilities, their shallow draft and the shallow water in which they work near the shore is to their advantage against the submarine's torpedoes.

Sea mines are a threat whether they have been actually placed, or if an announced intent to place them has been made. Landing craft have no protection against mines in the form of systems for detection or countermeasures such as degaussing[65] or a masker system.[66] However, the LCAC has an advantage over the LCU because it puts very little sound into the water when riding on its air cushion. Additionally, due to its construction of aluminum, the LCAC has a very low magnetic signature that is roughly equivalent to a top of the line mine countermeasures ship.[67] The main problem that mines in the littorals present is in how to remove them. Minesweeping of the past – where mechanical sweep gear was towed through the water to cut mines loose so they could be destroyed – doesn't work in shallow water. Instead, the mines must be individually located, identified, and neutralized by the technique of minehunting.[68]

Patrol boats will be an extremely difficult threat to the landing craft in the littorals. Their generally high rate of speed will make them hard to engage and such boats of today bristle with weapons. Though current landing craft are only able to mount

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[65] Degaussing is a mine countermeasure system which uses energized electrical cabling to produce a magnetic field to counteract a vessel's magnetic signature.
[66] A masker uses compressed air to "float" a vessel on a layer of bubbles and thereby mask or attenuate the mechanical sounds the vessel would otherwise put in the water.
[67] Don Campbell, Coastal Systems Station, Department of the Navy, telephone interview by author, 4 January 2001.
[68] Commander Tim S. Jorgensen, Royal Danish Navy, "U.S. Navy Operations in Littoral Waters: 2000 and Beyond," *Naval War College Review* LI, no.2, (Spring 1998): 22-23.

M60 or .50 caliber machine guns, they could be modified to carry 25mm or 30mm cannons. This could be just enough to improve the odds of success by a slow and steel-hulled landing craft against a fiberglass patrol boat with greater speed and maneuverability.

Coastal defenses will present threats in the form of both missile and gun batteries. Against gun batteries, speed would tend to favor the LCAC in its ability to present a difficult, fast-moving target. However, at 10 knots an LCU would not do nearly as well – but the gun battery must still identify and then target the craft with its fire control radar. Neither craft carries electronic countermeasures against fire control radar, but their small size and the possibility that they could be "lost" by the radar in between waves will slightly minimize their vulnerability to coastal guns.

Surface-to-surface missiles will pose unique problems based on the type of missile. Both craft have significant heat signatures from engine exhausts that would provide a good target for an infrared (IR) missile seeker, although they have rudimentary countermeasures that could assist in defeating an IR seeker. When on cushion, the LCAC puts a large amount of water spray and mist into the air that could partially mask its heat signature. Likewise, to attempt to lessen its heat output, an LCU could energize its CBR countermeasure washdown system to achieve a similar effect; however, the coverage and flow rate of the system is rather low.[69] Against missiles with radar seekers, it is anticipated that both craft would do rather well against the average surface-to-surface missile found around the world. A comparison of anti-surface missile characteristics

[69] A countermeasure washdown system uses an array of piping and nozzles to wet down the exterior of a vessel with salt water to keep CBR contaminants from landing on or adhering to the vessel.

following Table 3 shows why. The missiles listed in Table 3 are a representative sample of the most commonly exported weapons the Navy could face in the littorals.

Missile	Country	Cruise Altitude	Terminal Altitude
CSS-N-3 SEERSUCKER	China	30 m (97.5 ft)	8 m (26 ft)
MM-38 EXOCET	France	9 – 15 m (29 – 48 ft)	8 m* (26 ft)
OTOMAT/TESEO 3	Italy	30 m (97.5 ft)	2 m (6.5 ft)
SS-N-22 SUNBURN	Russia	20 m (65 ft)	7 m (22.7 ft)

* Note: EXOCET can descend to 2 – 5 m (6.5 – 16 ft) in calm seas.

Table 3 –Surface-to-Surface Missile Comparison

Source: *Jane's Naval Weapon Systems, Issue Thirty-Three*

Most surface-to-surface missiles are designed to seek targets that are of a substantial size in two categories – physical size and radar cross-section. Landing craft are small in both cases. Thus, it is hoped that the chances of a missile achieving a radar lock on the craft could be minimized, due to size and the whether the missile can distinguish the craft from the surrounding waves. If the craft is operating in even moderate seas with 2 to 5 foot swells (Sea State 3), the craft will "disappear" from the missile's view as it falls into the trough between two waves. When this is coupled with the low physical height of a landing craft – LCU height is 17' 9" and LCAC height is 23' 8" – the probability of a missile hit is expected to be low. [70] Two possible exceptions are the Otomat or the Exocet in calm seas. The LCU, while not exactly "stealthy," could be

[70] Fleet Marine Forces Reference Publication (FMFRP) 1-18, *Amphibious Ships and Landing Craft Data Book* (Washington, DC: GPO, 1991), 31-33. This is postulated based on terminal altitude versus craft dimensions due to the unclassified nature of this paper.

considered a low-observable craft from the standpoints of its size and ability to be engaged by enemy gun and missile systems.

Air-to-surface missiles pose a significant threat, because when launched from aircraft they generally dive to the target. In rough seas, landing craft could hide in the sea clutter that the waves would produce on a radar return, but pilots desiring to engage landing craft in the littoral will likely ensure that they obtain a good radar lock for their missile prior to firing. Additionally, many air-to-surface missiles operate in an optical guidance mode which allows for a higher probability of hitting the target. Table 4 shows a representative sample of air-to-surface missiles.

Missile	County	Terminal Altitude	Guidance
HY-4 / C-201	China	Steep dive	Radar
AM-39 EXOCET	France	8 m (26 ft)*	Radar
GABRIEL 3AS	Israel	1.5 – 4 m (5 – 13 ft)	Radar
AS-14 KEDGE	Russia	Dive from launch	Laser or TV
AS-17 KRYPTON	Russia	Dive	Radar

* Note: EXOCET can descend to 3 m (9.7 ft) in calm seas.

Table 4 – Air-to-Surface Missile Characteristics

Source: *Jane's Defence Equipment Library/Jane's Air Launched Weapons CD-ROM, 2000*

FUTURE MISSIONS

Landing craft in future operations will be expected to contribute to mission accomplishment in many ways: Over-the-Horizon lift, Amphibious Task Force (ATF) operations, MPF operations, independent operations, and Joint Command and Control.

This section addresses a number of the future missions that naval and joint forces could be called on to conduct in the littoral environment. Each one will be briefly described and evaluated for accomplishment by particular landing craft.

Amphibious Assault Echelon Operations. Assault Echelon Operations are defined as the conduct of opposed and unopposed landings on a belligerent shore to deliver troops, equipment, and cargo for combat operations. Both LCU and LCAC are capable of this mission by design, but a recent decision by the Navy's Expeditionary Warfare (EXWAR) Division has directed that only LCAC should be used for assault echelon operations in the future.[71] This appears to be a clear move toward establishing the tenets of OMFTS as doctrine.

Amphibious Assault Follow-on Echelon Operations. The ability to conduct landings to deliver afloat reserve troops, equipment, and cargo in support of sustained combat operations ashore defines AFOE operations. Both LCU and LCAC are capable of this mission. Transit distance to the beach from the ship being unloaded is a factor as well as the number of available crews. The LCU can work a longer crew day than an LCAC, and has a three to one ratio of maximum gross cargo weight in lift capacity.[72] Additionally, LCU(R) is planned to support systems such as the Amphibious Assault Bulk Fuel System (AABFS), which will call for the LCU to lay fuel hose from the shore to a tanker anchored from five to ten thousand feet offshore in order to provide fuel to forces ashore.[73]

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[71] Commander Thomas Nicolas, USN. Expeditionary Warfare (N753E) Staff Officer, Department of the Navy, Office of the Chief of Naval Operations, interview by author, 17 November 2000

[72] Kurt Sauter, *Analysis of Amphibious Mission Area Issues*, (Alexandria, VA: Center for Naval Analyses, December 1998), 8.

[73] LCU(X) MAA, 13.

Choke Point Transit Monitoring/Surveillance. In the event that naval combatant or amphibious ships are required to transit through a choke point, such as a narrow strait, landing craft could be called on to monitor opposing forces or conduct surveillance of the area. The small size of landing craft will allow them to surreptitiously reconnoiter an area without drawing noticeable attention to their presence. LCU seems better suited to this mission due to the quieter operation of its engines, whereas the noise associated with an LCAC would most certainly announce its location unless operating significantly offshore.

Clandestine Boat Operations. This entails the conduct of covert operations in order to insert or retrieve Navy Special Warfare (SEAL) swimmers, operate Marine Corps combat rubber raiding craft (CRRC) teams, or other special operations troops. In essence, the landing craft operates as a mobile strike base, carrying the needed troops onboard until the time is right for insertion and retrieval, if appropriate. These missions can be accomplished by both landing craft, and recently LCUs have worked closely with Navy SEAL divers during operations in the Persian Gulf.[74] The drawback to using an LCAC lies in its need to come off cushion and shut down engines to debark and embark swimmers, boats, and personnel. In contrast, the LCU is able to continue operation and movement, and thus draw less attention to its presence should it be sighted while underway, especially if rigged with deceptive lighting. Additionally, the LCU has crew support facilities to provide food, water, restrooms, and other amenities for the embarked crews.

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[74] Commander W. Curtis Hammill, USN, Commanding Officer, Assault Craft Unit ONE, Department of the Navy, interview by author, 17 January 2001. Cited hereafter as Commander W.C. Hammill, USN, interview.

Communications Relay Platform. This mission requires the landing craft to carry a modular container (often referred to as a CONEX box) or a vehicle with communications equipment in order to serve as a relay station for communications. The most likely scenario would be to relay communications from reconnaissance or surveillance teams that have gone ashore and are communicating via line-of-sight or low power radios, and thus could not communicate with a task force further out to sea. Time on station requirements will most likely require this mission to be handled by the LCU based on its ability to conduct extended independent operations.

Cryptographic/Signals Intelligence/ Electronic Support Platform. For this mission, the landing craft will carry a CONEX box or vehicle with equipment designed to intercept and analyze both encrypted and clear communications as well as electromagnetic spectrum signals from radars and other emitters. The ability of landing craft, the LCU in particular, to conduct independent and long range operations in areas away from the main task force will allow for collection of otherwise unavailable intelligence.

Deception Van Platform. Different from the previous described missions, here the idea is for the landing craft to broadcast its position. By embarking a CONEX box containing specialized emitters and radios, it an attempt to deceive opposing forces into believing that the task force has split or completely moved into another area. In the Cold War era, frigates often took on this task with equipment designed to draw Soviet reconnaissance forces away from carrier battle groups crossing the Pacific Ocean. Through the use of emitters that copied carrier-unique radars and playing tapes of flight

operations radio communications, the frigate often successfully drew long-range Soviet aircraft away from the battle group. Again, with its longer mission endurance, the LCU is best suited to this mission.

Force Protection Operations. Landing craft can conduct physical force protection operations in a variety of ways. They can act as picket boats to screen a task force at sea, a shore base, or a harbor area from small craft that could otherwise approach unobserved. Because of the ability to carry troops and weapons in the open during operation, the LCU is the craft of choice to accomplish this mission; however it will need to patrol in an inner ring of defense due to its slower speeds. In the event that a Special Boat Unit or Inshore Boat Unit has been tasked to provide smaller and faster boats for harbor defense, for example, the LCU can act as a mobile support base. Functioning in such as role, the LCU could provide fuel, water, and crew support facilities.

In a recent actual example of force protection, during East Timor operations an LCU provided safe haven for U.S. personnel at night due to security concerns. An LCU would pick up United Nations Peacekeeping Force personnel near sunset and then anchor offshore, thus allowing a defensible position the troops did not have ashore.[75] Finally, the crypto/signals intelligence mission also adds to force protection by providing needed intelligence on opposing force intentions.

General/Utility Support. Under this "catch-all" heading fall a variety of small and unheralded missions: ammunition transfer, diving operations, and training support to amphibious ships are a few examples. Both vessels are capable of conducting these missions, but the LCAC has the disadvantage of needing to shut down its engines to

[75] Commander W.C. Hammill, USN, interview.

allow personnel into its well deck to handle cargo and equipment. During recent operations in Yemen following the attack on USS COLE (DDG-67), an LCU from the deployed USS TARAWA (LHA-1) ARG was chosen to act as a diving support platform for divers conducting underwater surveys of the COLE; it also delivered meals to the COLE from TARAWA.[76]

Humanitarian Assistance Operations (HAO). The task of HAO often demands movement of large numbers of personnel and a vast volume of cargo to support mission goals ashore. Additionally, HAO is usually conducted in a benign environment; hence the host ship operates closer to shore. Both landing craft are capable of supporting HAO, which typically demands high-throughput of supplies and foodstuffs. Because of its payload advantage and ability to operate for longer periods, the LCU is better adapted to this mission. This has been shown lately as the operations in East Timor have changed from peacekeeping operations to HAO.

Landings in Restricted Waters. In the event of need to conduct a troop or equipment landing in an enclosed harbor, canal, or river, a landing craft must be able to navigate precisely through narrow confines to the landing area. Both craft are highly maneuverable and well-suited to this task. The LCAC has the advantage of not being hindered by depth of water, but must be mindful of collateral damage it could cause to surrounding areas caused by its propeller wash and the noise it makes during approach to an area. If the landing is to be covert, and water depth supports a displacement craft, the LCU may be a better selection to execute this type of tasking.

[76] Commander W.C. Hammill, USN, interview.

Logistics Support. As the Navy and Marine Corps move toward the ideals described in OMFTS and STOM, they will conduct forward operations along the lines of "seabasing."[77] This seabasing, or Seabased Logistics, concept maintains most of the logistics and support items on amphibious ships at sea, sending them to shore for "just in time" delivery. Based on requirements for these items, either the LCAC or LCU could function effectively as the delivery platform. The LCAC is ideally suited for swift delivery of high urgency of need items or small loads, while the LCU is more suitable for normal deliveries or when the large quantity of supplies calls for its cargo carrying capacity.

Maritime Interception Operations (MIO) Support. To conduct this mission, landing craft must patrol and board vessels suspected of carrying contraband with an embarked boarding team. As mentioned earlier, LCUs have conducted this sort of operation already, and can and probably will continue to do so in the future. Though the ability to conduct extended independent operations is a plus for this mission, it is not absolutely necessary. However, LCACs would not be suited for it due to the need to have personnel on deck for boarding operations.

Maritime Prepositioning Force (MPF) Offload/Transfer. Though MPF operations are normally conducted in a permissive environment, and ideally pierside in a port, future offload of MPF shipping may call for alternative measures. OMFTS and STOM call for the ability to conduct future MPF operations from over-the-horizon. If a permissive landing environment has not been achieved, one possibility would be to use landing craft to shuttle equipment from MPF ships to Navy amphibious ships for further transport to

[77] STOM, II-22 – II-23. Seabasing supports the OMFTS and STOM concept of maintaining force support at sea vice building up forces, equipment, and logistics on shore.

the landing area. Though this would require accommodating seas and weather, the LCU would perform this task more efficiently than the LCAC. Assuming that the two ships are close together, the speed advantage of the LCAC would be minimally advantageous, while the LCU's greater cargo lift capability would be very favorable to mission accomplishment.

Mine Warfare Support Platform. Landing craft can be utilized in the littorals to conduct both offensive and defensive mining operations. In offensive operations, they can be used to lay mines. LCUs conducted operations like this during exercise Kernel Blitz 99, off the southern California coast, but LCACs are equally suited to the task. For defensive operations, they can embark very shallow water mine countermeasures (VSW MCM) teams and take them to areas where mines are to be cleared. LCUs would perform better at this mission, since teams would need to work frequently in the well deck and possibly over the side during mine clearance operations.

Noncombatant Evacuation Operations (NEO). An example of NEO operations would be the evacuation of civilian personnel from a U.S. Embassy located in an area of civil turmoil. Landing craft could be used to move personnel from shore-to-ship for processing and transport to a safe haven. Both types of landing craft are easily capable of this mission. Speed versus quantity of personnel to be moved would dictate selection of landing craft. If the number of personnel to be moved is less that 180, an LCAC with PTM is the best choice. If there are larger numbers to be moved, LCUs will accomplish the mission slightly slower but with fewer runs to the beach.

Port Opening/Salvage Operations. As part of an enabling force for MPF operations, landing craft could be used to clear debris and small sunken vessels cluttering a harbor intended for MPF offload. During the Vietnam-era LCUs did this with great success. Though LCACs could also be fitted to perform salvage tasks, due to their smaller displacement and lift capability they could not raise or transport the same size loads that an LCU could handle.

Riverine Operations. Operations in riverine areas would most likely be conducted during long-term presence or build-up operations, or possibly in response to resistance fighters or insurgents in a local area. As in Vietnam, modifications would be required to tailor landing craft to the mission at hand. This could include extra weaponry, armor plating, and crew augmentees to assist in round-the-clock operations and to man weapons. Due to its inability to operate needed weapons for both self-defense and offensive operations while operating on cushion, LCAC is not suited for this mission.

Mission	Suitable Craft	Comment
Assault Echelon Operations	Both	**LCAC best suited** per direction from EXWAR
Assault Follow-on Echelon Operations	**Both**	Distance to beach a primary decision factor
Choke Point Monitoring/Surveillance	**LCU**	Stealth (quietness) capability
Clandestine Boat Operations	Both	**LCU better suited** (quietness)
Communications Relay Platform	**LCU**	Mission endurance
Crypto/Signals Intelligence/Electronic Support Platform	**LCU**	Independent operations, mission endurance
Deception Van Platform	**LCU**	Mission endurance
Force Protection Operations	**LCU**	Embarked crew support capability
General/Utility Support	Both	**LCU better suited**
Humanitarian Assistance Operations	Both	**LCU better suited**
Landings in Restricted Waters	**Both**	LCAC unhindered by water depth
Logistics Support	**Both**	LCAC faster, LCU hauls more
Maritime Interception Operations	**LCU**	LCU can carry troops on deck
MPF Offload/Transfer	**LCU**	Greater cargo capability
Mine Warfare Support Platform	Both	**LCU better suited**
Noncombatant Evacuation Operations	**Both**	LCAC for less than 180 personnel, LCU if more
Port Opening/Salvage Operations	Both	**LCU better suited** (lift capacity)
Riverine Operations	**LCU**	Mission endurance

Table 5 – Mission Suitability Synopsis

MISSION ANALYSIS – WHICH CRAFT IS BETTER?

As Table 5 shows, of the eighteen possible aforementioned future missions, the LCAC appears to be best suited in one instance and is equally suited with the LCU for mission accomplishment in four cases. The other thirteen missions were shown to be best accomplished by the LCU. In most cases, the LCU's ability to conduct independent operations of extended duration is what makes it the better choice of craft for a particular mission.

This is not to say that the LCU can replace the LCAC. The LCAC was built to conduct high-speed, over-the-horizon transport; the kind of ship-to-objective lift required for OMFTS and Seabased Logistics. To operate successfully, especially for extended periods, in the littorals calls for a landing craft with different capabilities. The Mission Need Statement for LCU(R), though seemingly oriented on amphibious capabilities, has a decided littoral emphasis as it defines the following general missions for LCU(R):

> Primary.
>
> (a) To rapidly transport heavy material and personnel from amphibious warships, MPF Ships, and other platforms at sea to points on shore…
>
> (b) To transport vehicles, heavy cargo and personnel intra-theater…or ship-to-ship.
>
> (c) To provide a platform from which to deploy the Amphibious Assault Bulk Fuel System (AABFS) and future D-Day fuel systems.
>
> (d) To provide general utility craft services to the Naval Beach Groups.
>
> Secondary.
>
> (a) To provide mobile seabasing for Special Operations forces and riverine forces requiring littoral support.
>
> (b) To serve as an alternative launch, recovery and salvage platform for the AAAV.[78]

The previous analysis conducted shows that the LCU is an incredibly versatile craft – the "U" does stand for "Utility" – and is well suited to conduct and successfully accomplish most of the wide range of missions envisioned in the littoral environment of the future. These missions, when performed by landing craft, will add to the overall abilities of a naval or joint task force and thereby make them a force multiplier by definition.

[78] LCU(R) MNS, 2.

LITTORAL EMPLOYMENT OPTIONS (CONCLUSION)

The task force commander of the future will face a variety of unpredictable and diverse situations in the littorals. They will span the "spectrum of conflict" from low intensity crises such as humanitarian and disaster assistance, to medium intensity crises such as NEO or small-scale contingencies, to a high intensity crisis or major theater war. Forward-deployed forces responding to such situations will not always have all the necessary forces desired for assigned tasking immediately available for use.

In a situation where there is a paucity of assets, or even when all asset desires are met, the use of landing craft to fulfill missions of Navy combatant or amphibious ships can and will serve as a force multiplier. By using landing craft in littoral operations, particularly the future LCU, the task force can maximize its ability to accomplish many tasks while keeping the high value ships further offshore or over-the-horizon. Putting more distance between these ships and the shore removes them from a number of threats and allows for early detection of others.

For example, if an ARG is operating along with a DDG for protection, the DDG will be constrained to stay close to the ARG to properly guard it with its missile engagement envelope from enemy missiles or aircraft approaching from shore. In the event that it is necessary to insert a recon team or conduct intelligence gathering operations, an LCU could easily be employed to accomplish these missions instead of sending the DDG or an amphibious ship closer to shore. Though the LCU has few self-defense capabilities, its small size is a passive protective feature in and of itself. By using the LCU, the mission is accomplished with less overall risk, the ARG keeps its protection intact, and the high value ships are kept from harm.

In the event that a successful enemy attack is carried out, the loss of or damage to a $15 million landing craft with a crew of 11 will be easier to mitigate than the loss of a $1 billion state-of-the-art destroyer and a crew of 350. It may also have less overall effect on strategic and operational decisionmaking and the will to respond. Though this seems a callous approach, the overriding concerns of military leaders, politicians, and the public are to limit the loss of life and equipment while attaining mission accomplishment.

The LCU and its future replacement will be exceptionally well suited to handle a large number of the myriad tasks that a surface combatant ship could be called on to perform in littoral waters. They will also be equally able to continue into inland waters and pursue riverine missions. Thus, the LCU(R) will provide flexibility for future naval and joint force commanders and provide the items required of a force multiplier – an increase in the combat potential of a force and enhanced mission accomplishment probability.

Appendix A

List of Acronyms

AAAV .... ADVANCED AMPHIBIOUS ASSAULT VEHICLE
AABFS .... AMPHIBIOUS ASSAULT BULK FUEL SYSTEM
ACU .... ASSAULT CRAFT UNIT
AE .... ASSAULT ECHELON
AFOE .... ASSAULT FOLLOW-ON ECHELON
ASPB .... ASSAULT SUPPORT PATROL BOAT
ARG .... AMPHIBIOUS READY GROUP
ATC .... ARMORED TROOP CARRIER
ATF .... AMPHIBIOUS TASK FORCE
CBR .... CHEMICAL, BIOLOGICAL, RADIOLOGICAL
CCB .... COMMAND AND CONTROL BOAT
CRRC .... COMBAT RUBBER RAIDING CRAFT
DDG .... DESTROYER, GUIDED-MISSILE
FY .... FISCAL YEAR
GPS .... GLOBAL POSITIONING SYSTEM
HAO .... HUMANITARIAN ASSISTANCE OPERATIONS
IR .... INFRA-RED
JLOTS .... JOINT LOGISTICS OVER THE SHORE
LCAC .... LANDING CRAFT, AIR CUSHION
LCM .... LANDING CRAFT, MECHANIZED
LCT .... LANDING CRAFT, TANK
LCU .... LANDING CRAFT, UTILITY
LCU-R .... LANDING CRAFT, UTILITY, REPLACEMENT
LCU-X .... LANDING CRAFT, UTILITY, EXPERIMENTAL

LCVP ....LANDING CRAFT, VEHICLE, PERSONNEL
LHA ....AMPHIBIOUS ASSAULT SHIP (GENERAL PURPOSE)
LHD ....AMPHIBIOUS ASSAULT SHIP (MULTI PURPOSE)
LOTS..LOGISTICS OVER THE SHORE
LPD.. AMPHIBIOUS TRANSPORT, DOCK
LSD...LANDING SHIP, DOCK
LST...LANDING SHIP, TANK
MIO..MARITIME INTERCEPTION OPERATIONS
MORE ....MILITARY OPERATIONS IN A RIVERINE ENVIRONMENT
MPF .... MARITIME PREPOSITIONING FORCE
MRF ....MOBILE RIVERINE FORCE
MSB..MINESWEEPING BOAT
MSI ....MODIFIED SURF INDEX
NEO ....NON-COMBATANT EVACUATION OPERATION
NOC... NAVY OPERATIONAL CONCEPT
OMFTS ....OPERATIONAL MANEUVER FROM THE SEA
OTH ....OVER-THE-HORIZON
PACV...PATROL AIR CUSHION VEHICLE
PBR..PATROL BOAT, RIVER
PCF ....PATROL CRAFT, FAST
POE..PROJECTED OPERATING ENVIRONMENT
PTM ....PERSONNEL TRANSPORT MODULE
ROC ....REQUIRED OPERATIONAL CAPABILITIES
SAR.. SEARCH AND RESCUE
SIGNINT..SIGNALS INTELLIGENCE
SLEP ....SERVICE LIFE EXTENSION PROGRAM
STOM .... SHIP-TO-OBJECTIVE MANEUVER
VSW MCM.........................VERY SHALLOW WATER MINE COUNTERMEASURES

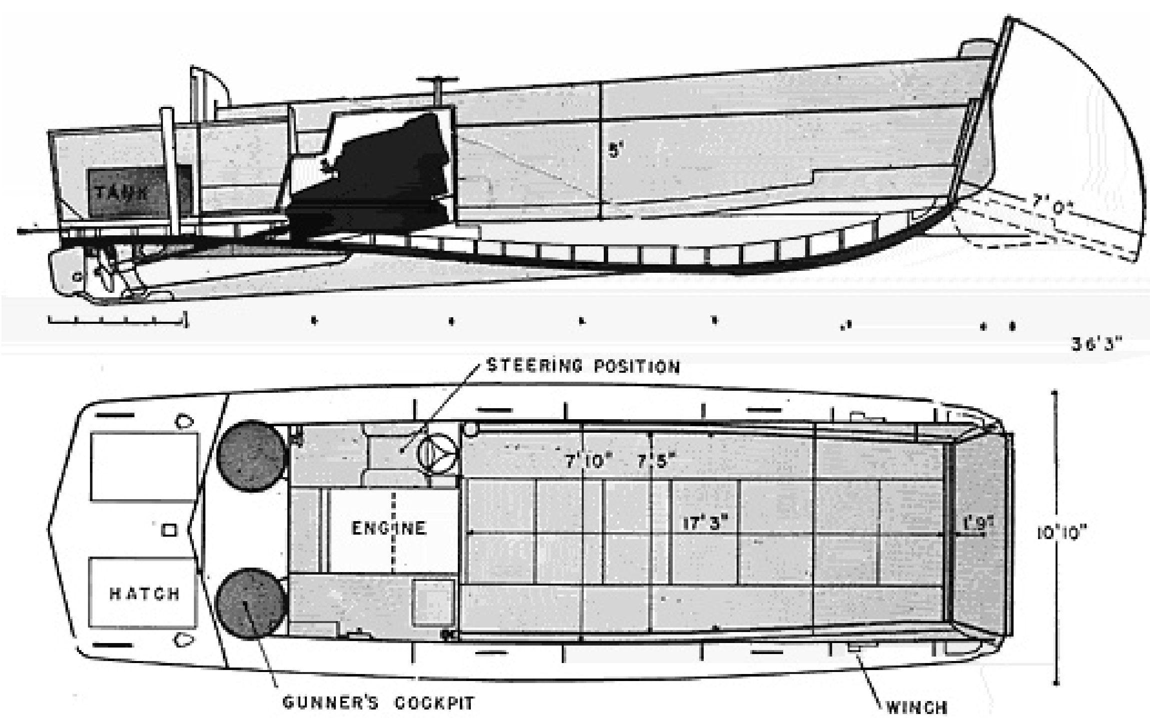
Appendix B

Combatant and Landing Craft

This Appendix will present a collection of information on the various combatant and landing craft discussed in this paper. These craft have seen use throughout the littoral regions of the world in amphibious landings, coastal patrols and riverine operations.

Landing Craft, Vehicle, Personnel (LCVP) *aka:* "Higgins Boat"

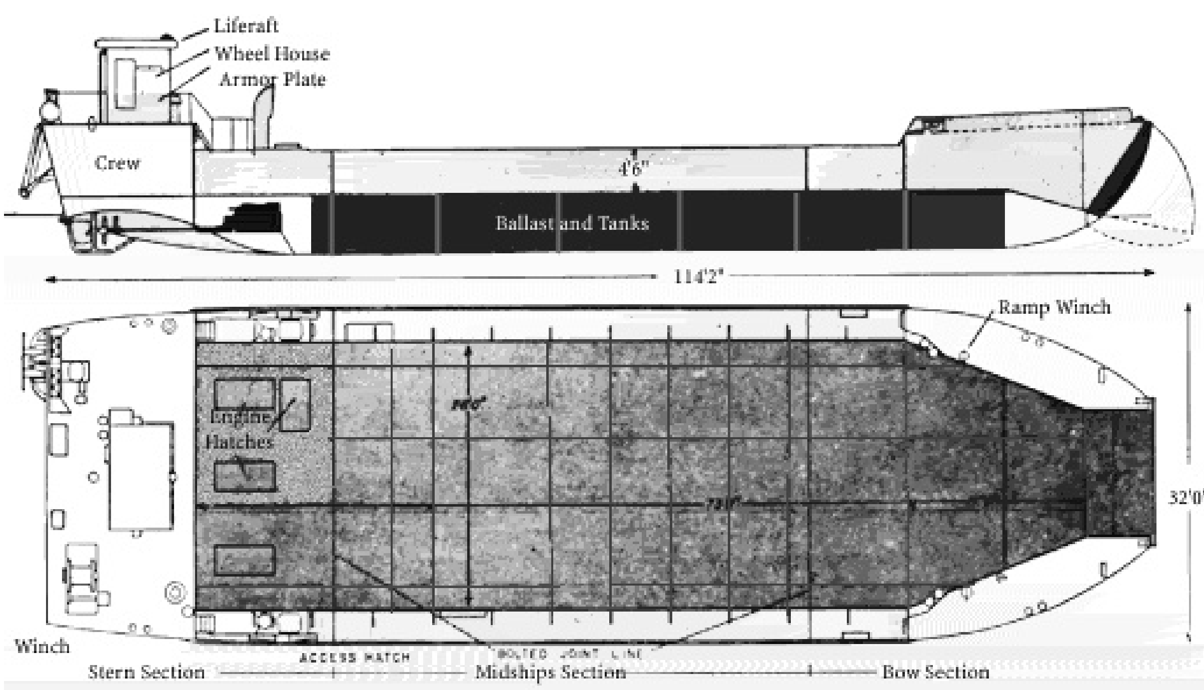
Hull:	Originally wood (oak, pine and mahogany), later Steel
Displacement:	18,000 lbs. (light)
Length:	36'3"
Beam:	10'10"
Draft:	3' aft, 2'2" forward
Speed:	9 knots
Armament:	Two .30-cal MGs
Complement:	3 enlisted
Capacity:	36 troops or 6,000 lb. vehicle or 8,100 lb. general cargo
Propulsion:	225 hp Diesel or 250 hp gasoline engine
Notes:	This craft was designed specifically to meet the needs of the amphibious fleet during WW II. It was the predecessor of the LCM.



Higgins Boat

Landing Craft, Tank (LCT) - Mark 5 Type

Hull:	Steel
Displacement:	286 tons (landing)
Length:	117'6"
Beam:	32'
Draft:	2'10" forward, 4'2" aft (landing)
Speed:	8 knots
Armament:	Two 20mm
Complement:	One officer, 12 enlisted
Capacity:	Five 30-ton or four 40-ton or three 50-ton tanks; or nine trucks; or 150 tons cargo
Propulsion:	Three 225 hp diesels, triple screws
Notes:	Another WW II craft, it was eventually developed into the LCU. The LCT Mark 6 version was developed in mid-1944 and made use of lessons learned from D-Day. It was built with a stern gate which allowed for “drive-through” of vehicles. The LCT Mark 6 very much resembles the modern LCU.



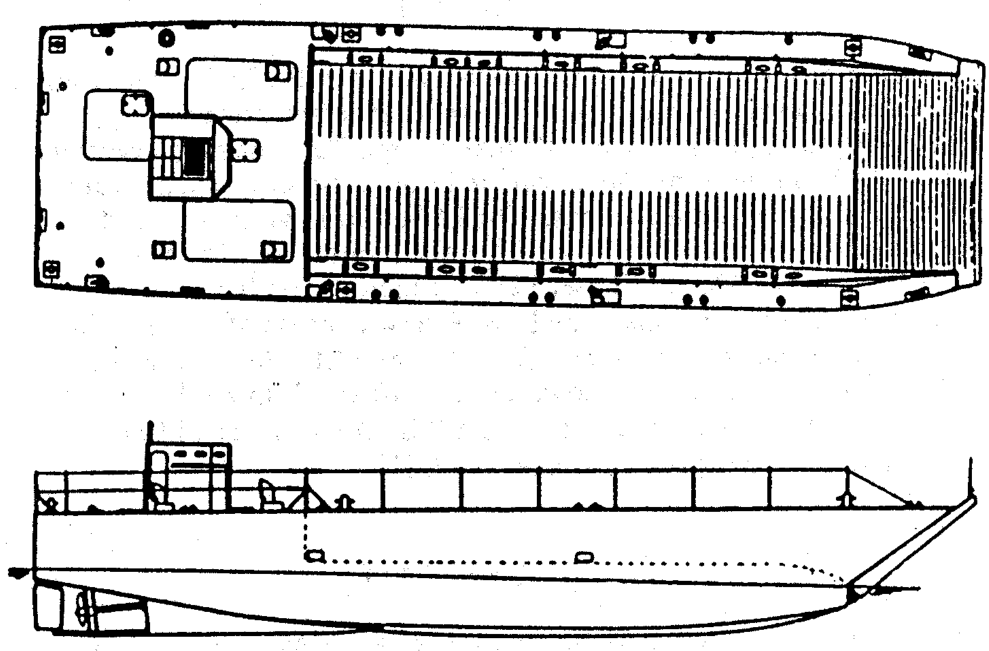
Landing Craft Tank

Landing Craft, Mechanized (LCM) Mark 6 (LCM-6)

Hull:	Steel
Displacement:	64 tons full load
Length:	56’2”
Beam:	14’
Speed:	9 kts (10.3 mph)
Crew:	5 enlisted
Capacity:	34 tons or 80 troops
Propulsion:	Two marine diesel engines, twin screw
Range:	130 miles at 9 kts

Landing Craft, Mechanized (LCM) Mark 8 (LCM-8)

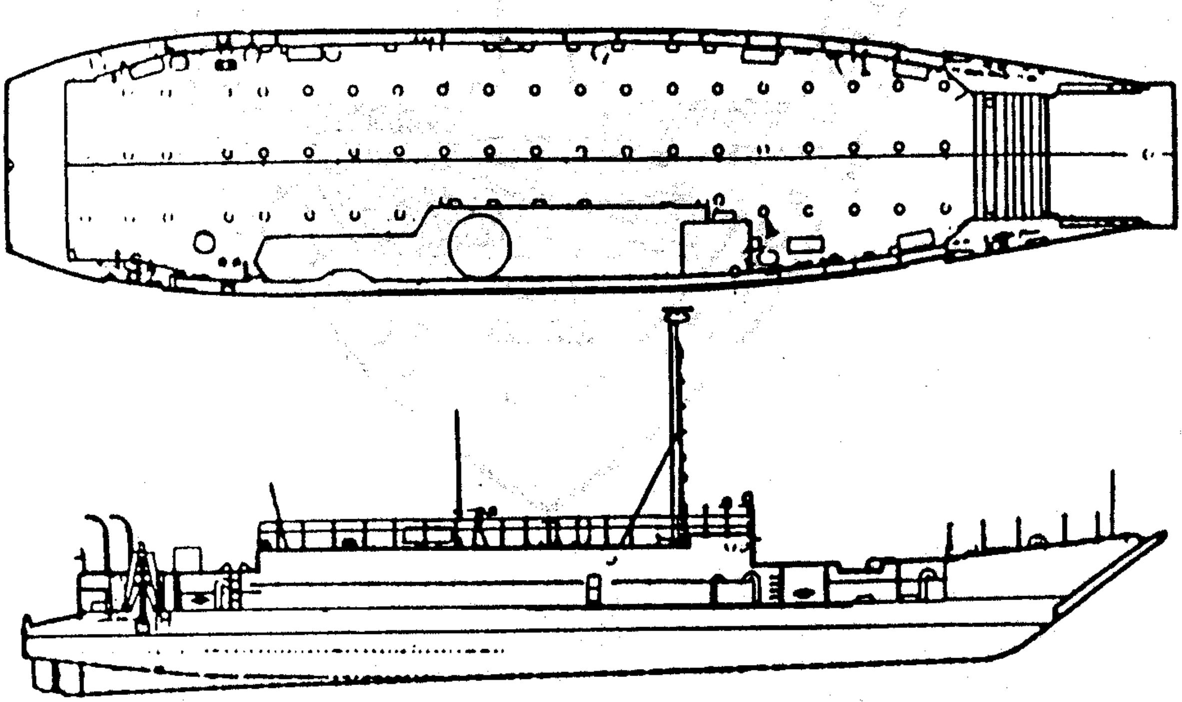
Hull:	Steel
Displacement:	75 tons full load
Length:	73’ 8”
Beam:	21’
Speed:	12 kts (13.8 mph)
Crew:	5 enlisted
Capacity:	60 tons
Military lift:	One M60 tank or 200 troops
Propulsion:	Two Detroit 12V-71 Diesel engines; 680hp sustained; twin shafts
Range:	190 miles at 9kts full load
Notes:	This craft is currently in use for training and MPF support.



Landing Craft Mechanized-8

Landing Craft Utility (LCU), LCU 1610, 1627 and 1646 Class

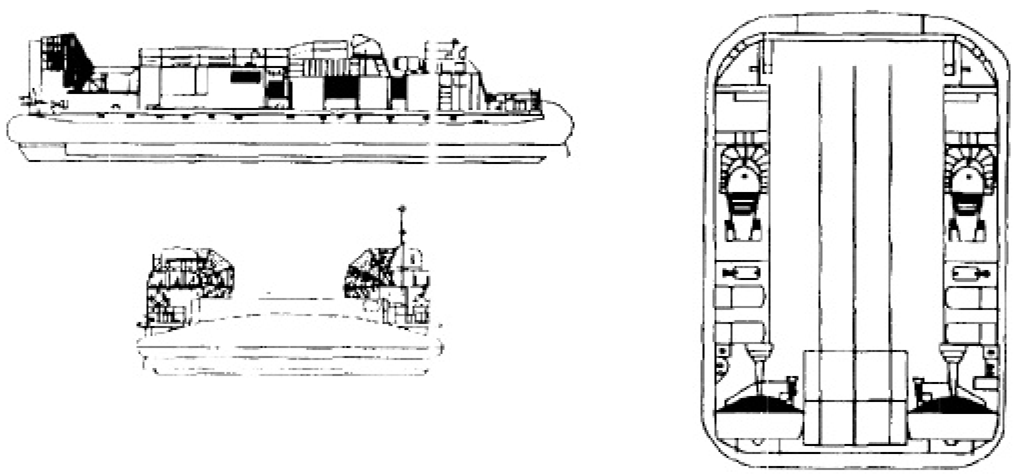
Hull:	Steel
Displacement:	200 tons light; 375 tons full load
Length:	134’ 11”
Beam:	29’
Draft:	3’ 6” forward, 6” 10” aft
Speed:	11 kts (12.7 mph)
Armament:	Two 12.7mm MGs, can mount four .50 cal MGs
Crew:	14 enlisted wartime (11 peacetime)
Capacity:	170 tons (172.73 metric tons)
Military Lift:	125 tons of cargo
Propulsion:	Two Detroit 12V-71 Diesel engines, twin shaft, 680 hp sustained
Range:	1200 miles at 8 knots
Notes:	All three classes currently in use.



Landing Craft Utility

Landing Craft, Air Cushion (LCAC)

Hull:	Aluminum
Displacement:	87.2 tons light; 170-182 tons full load
Length:	87’ 11”
Beam:	47’
Speed:	40+ knots (46+ mph) with full load
Armament:	Two 12.7mm MGs. Gun mounts will support: M-2HB .50 cal MG, Mk-19 Mod3 40mm grenade launcher; M-60 machine gun
Crew:	5 enlisted
Load Capacity:	60 tons / 75 ton overload
Military lift:	24 troops or 1 Main Battle Tank
Propulsion:	Four Avco-Lycoming TF-40B gas turbines (2 for propulsion/2 for lift); 16,000 hp sustained; two shrouded reversible pitch airscrews; four double-entry fans, centrifugal or mixed flow (lift)
Range:	200 miles at 40 kts with payload / 300 miles at 35 kts with payload



Landing Craft Air Cushion

Patrol Boat, River – Mark I (PBR-I)

Hull:	Lightweight fiberglass
Weight:	18,000 lbs (without crew and ammo)
Length:	31’
Beam:	11’ 7”
Draft:	9” underway
Speed:	28 knots
Armament:	Twin .50 caliber Machine Gun turret in the bow, Single .50 caliber Machine Gun in the stern, M-60 Machine Gun, M-18 40mm Grenade Launcher, Crew's Small Arms (4 M-16s and Captain's .45 M1911A1) Additional Armor: 90mm Recoilless Rifles, 60mm Mortars, flamethrowers, 20mm Cannons
Crew:	4 enlisted
Propulsion:	Two 250 HP diesels each connected to a 6” diameter Jacuzzi water jet, capable of 6000 gallons per minute discharge.
Notes:	Boats patrol in pairs, with additional Chief Petty Officer as Patrol Officer

Patrol Boat, River – Mark II (PBR-II)

Hull:	Lightweight fiberglass
Weight:	15550 lbs (without crew)
Length:	31’ 11”
Beam:	11’ 7”
Draft:	9” underway
Speed:	28 knots
Armament:	Twin .50 caliber Machine Gun turret in the bow, Single .50 caliber Machine Gun in the stern, M-60 Machine Gun, two M-79 40mm Grenade Launcher, 12-gage shotgun, Crew's Small Arms (3 M-16s and .38 caliber revolver). Additional Armament: 90mm Recoilless Rifles, 60mm Mortars, flamethrowers, 20mm Cannons
Crew:	4 enlisted
Propulsion:	Two 250 HP diesels each connected to a 8” diameter Jacuzzi water jet, capable of 9600 gallons per minute discharge
Notes:	Boats patrol in pairs, with additional Chief Petty Officer as Patrol Officer

Armored Troop Carrier (ATC)

Hull:	Steel
Displacement:	61 tons
Length:	56’
Beam:	17’ 6”
Draft:	4 to 4 ½’
Speed:	9 kts
Armament:	Two .50 caliber MG, one 20mm cannon, two M-60 MGs, two MK 18 grenade launchers, various small arms
Complement:	5 enlisted
Capacity:	
Propulsion:	Two marine diesel engines, twin screw
Notes:	Converted LCM-6 landing craft. Some were fitted with helicopter pads above the troop area to allow for medevac.

Assault Support Patrol Boat (ASPB)

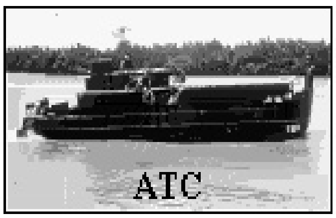
Hull:	Steel
Displacement:	
Length:	50’
Beam:	16’
Draft:	
Speed:	15 kts
Armament:	Two 30 caliber MGs, grenade launcher, one 20mm cannon
forward,	
	one 81mm mortar aft, various small arms
Complement:	5 enlisted
Propulsion:	Two marine diesel engines, twin screw

Command and Communications Boat (CCB)

Hull:	Steel
Displacement:	72 tons light
Length:	60’ 6”
Beam:	17’ 6”
Draft:	approx. 3 ½’
Speed:	9 kts
Armament:	One 40mm cannon, one 20mm cannon, two .50 caliber MG, two M-60 MGs, various small arms
Complement:	11 enlisted plus Division Commander and staff
Propulsion:	Two marine diesel engines, twin screw
Notes:	Much like the Monitor except the mortar pit was replaced with a communications module.

Monitor

Hull:	Steel
Displacement:	82 tons light
Length:	60’ 6”
Beam:	17’ 6”
Draft:	approx. 3 ½’
Speed:	9 kts
Armament:	One 40mm cannon, one 20mm cannon, three .50 caliber MGs, two MK 18 grenade launchers, one 81mm mortar, various small arms
Complement:	11 enlisted
Propulsion:	Two marine diesel engines, twin screws
Notes:	Converted LCM-6. Later models were fitted with guns of up to 105mm.



Patrol Air Cushion Vehicle (PACV)

Weight:	7 tons
Length:	39’ 2”
Beam:	22’ 9”
Speed:	70 kts
Armament:	One twin 50 caliber MG, two M-60 MG mounted in side windows, one M-60 MG firing aft.
Capacity:	20 passengers or 2 tons cargo
Propulsion:	Turbojet marine engine; one four-bladed variable pitch 9’ blade for forward movement, one 7’ diameter blade for lift.
Range:	240 nautical miles at 70 kts, 3.5 hours endurance

Appendix C

Modified Surf Index

This Appendix will present excepts from the *Joint Surf Manual* to provide background on how the Modified Surf Index (MSI) is calculated for displacement craft and on limits used for non-displacement craft like the LCAC.

1102. MODIFIED SURF INDEX CALCULATION. When applied to a known or forecast surf condition, the modified surf index calculation provides the commander with an objective method of arriving at a safe and reasonable decision with respect to committing landing craft and amphibious vehicles. Limiting surf conditions for training operations acceptable for routine operations as calculated by the objective method described below. CAUTION: Surf capability of landing craft and amphibious vehicles computed by this method assumes such craft are in good condition. It does not take into consideration the state of training of personnel or the state of maintenance of equipment.

SURF ELEMENTS.

Significant Breaker Height (Alpha) – the mean value of the 1/3 highest breakers on the beach, measured to the nearest half foot.

Period (Charlie) – the time interval between breakers measured to the nearest half-second.

Breaker Type (Delta) – a breaker is a wave tripped by shoal water. The three types of breakers are spilling, plunging, and surging.

A breaking process characterizes the spilling breaker where the wave peaks up until it is very steep but not vertical. Only the topmost portion of the wave curls over and descends on the forward slope of the advancing wave where it then slides down into the trough.

In the plunging type, the wave peaks up until it is an advancing vertical wall of water. The crest then curls far over and descends violently into the preceding trough where the water surface is essentially horizontal. A considerable amount of air is trapped in this process and the air escapes explosively behind the wave, throwing water high above the surface.

In the surging breaker, the wave crest tends to advance faster than the base of the wave to suggest the formation of a plunging breaker. However, the wave then advances faster than the crest, the plunging is arrested, and the breaker surges up the beach face as a wall of water which may or may not be whitewater.

Angle of Breaker with the Beach (Echo) – the acute angle, in degrees, a breaker makes with the beach.

Littoral Current (Foxtrot) – the alongshore current, measured to the nearest tenth knot.

Relative Wind (Hotel) – the acute angle, in degrees, between the direction of wind and a line normal to the beach edge

Secondary Wave (Hotel) – a series of waves superimposed upon another series differing in height, period or angle of approach to the beach.

1103. MODIFIED SURF INDEX CALCULATIONS

SIGNIFICANT BREAKER HEIGHT (Alpha) _____Feet
Enter Significant Breaker Height in feet ___.___

BREAKER PERIOD (Charlie) _____ Seconds
Enter value from Breaker Period Modification Table ___.___

BREAKER TYPE (Delta) ____%Spilling____%Plunging____%Surging
Enter value from Spilling Breaker
Modification Table or Surging Breaker Modification Table (a) ___.___

LITTORAL CURRENT (Foxtrot) ______Knots
Enter value from Littoral Current
Modification Table (b) ___.___
Enter the larger of (x) and (b) from above ___.___

REL WIND (Hotel) _____ Kts_____Deg Onshore/Offshore
Enter value from
Wind Modification Table ___.___

SECONDARY WAVE HEIGHT (Hotel) _____Feet
Enter Secondary wave height in feet (if applicable) ___.___

MODIFIED SURF INDEX
Sum all entries in the right hand column to obtain Modified Surf Index ___.___

The Modified Surf Limit is the maximum that should be attempted for routine operations. If the Modified Surf Index exceeds the Modified Surf Limit of the craft or vehicle, the landing is not feasible without increasing the casualty rate. If the Modified Surf Index is less than the Modified Surf Limit of the craft, the landing is feasible.

1104. MODIFIED SURF INDEX CALCULATION TABLES

See tables on the last two pages of this Appendix for Breaker Period Modification Table, Spilling Breaker Modification Table, Surging Breaker Modification Table, Wave Angle Modification Table, Littoral Current Modification Table and Wind Modification Tables.

1105. MODIFIED SURF LIMITS FOR LANDING CRAFT

Craft/Vehicle	Modified Surf Limit
LCM 6	8
LCM 8	8
LCU	12
LCVP	5
LVTP-5	8
LARC	6
CAUSEWAY (3x15)	6

1106. MAXIMUM SURF CAPABILITIES FOR LCAC . The Modified Surf Index is not applicable to the LCAC. Limiting conditions for operating the LCAC in the surf zone is based on load size and significant breaker height only.

LOAD	SIG. BREAKER HEIGHT
75 tons overload	0-4 feet
60 tons normal payload	4-8 feet
45 tons reduced payload	8-12 feet

TABLE 12-1
LCAC ON CUSHION OPERATION IN SURF

Characteristic	**Low Surf**	**Med Surf**	**High Surf**
Height	0-4 ft	4-8 ft	8-12 ft
Payload	60 tons (75 tons overload)	60 tons	Reduce payload to 45 tons for 12-ft or higher surf Negotiation of high surf depends on skill level of Operator (note 1)
Heading to Surf Line (deg.)	90±45	90±10	90±10
Max Speed During Beach Approaches	50 kt (note 1)	30 kt (note 1)	20 kt (note 1)
Max Speed During Beach Departures	30 kt (note 2)	20 kt	10 kt

Note 1 - Inside surf line, craft speed is adjusted to coincide with wave speed
Note 2 - Speed should be reduced with a steep beach gradient to avoid plow-in and hard structure damage.

1104. **MODIFIED SURF INDEX CALCULATION TABLES**

Breaker Period Modification Table

Breaker Period (sec)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	≥ 5
≥ 17	0.0	0.0	0.0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.0
16	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5	-0.7
15	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.3	-0.3
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.2	0.3	0.3
12	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.3	0.4	0.5	0.7
11	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0
10	0.0	0.0	0.1	0.1	0.2	0.3	0.5	0.7	0.9	1.1	1.3
9	0.0	0.0	0.1	0.1	0.3	0.3	0.6	0.8	1.1	1.3	1.7
≤ 8	0.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.6	2.0

Breaker Height (feet)

Spilling Breaker Modification Table

Percent Spilling Breakers	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	≥ 5
100	0.0	-0.1	-0.2	-0.5	-0.8	-1.3	-1.8	-2.5	-3.2	-4.1	-5.0
90	0.0	0.0	-0.2	-0.4	-0.7	-1.1	-1.6	-2.2	-2.9	-3.6	-4.5
80	0.0	0.0	-0.2	-0.4	-0.6	-1.0	-1.4	-2.0	-2.6	-3.2	-4.0
70	0.0	0.0	-0.1	-0.3	-0.6	-0.9	-1.3	-1.7	-2.2	-2.8	-3.5
60	0.0	0.0	-0.1	-0.3	-0.5	-0.8	-1.1	-1.5	-1.9	-2.4	-3.0
50	0.0	0.0	-0.1	-0.2	-0.4	-0.6	-0.9	-1.2	-1.6	-2.0	-2.5
40	0.0	0.0	-0.1	-0.2	-0.3	-0.5	-0.7	-1.0	-1.3	-1.6	-2.0
30	0.0	0.0	-0.1	-0.1	-0.2	-0.4	-0.5	-0.7	-1.0	-1.2	-1.5
20	0.0	0.0	0.0	-0.1	-0.2	-0.3	-0.4	-0.5	-0.6	-0.8	-1.0
10	0.0	0.0	0.0	0.0	-0.1	-0.1	-0.2	-0.2	-0.3	-0.4	-0.5
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Breaker Height (feet)

(Note: No Modification for Plunging Breakers)

Surging Breaker Modification Table

Percent Surging Breakers	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	≥ 5
100	0.0	0.1	0.2	0.5	0.8	1.3	1.8	2.5	3.2	4.1	5.0
90	0.0	0.0	0.2	0.4	0.8	1.2	1.7	2.3	3.0	3.8	4.7
80	0.0	0.0	0.2	0.4	0.7	1.1	1.6	2.2	2.9	3.6	4.5
70	0.0	0.0	0.2	0.4	0.6	1.0	1.5	2.0	2.7	3.4	4.2
60	0.0	0.0	0.2	0.3	0.6	1.0	1.4	1.9	2.5	3.1	3.9
50	0.0	0.0	0.1	0.3	0.6	0.9	1.3	1.7	2.3	2.9	3.5
40	0.0	0.0	0.1	0.2	0.5	0.8	1.1	1.5	2.0	2.6	3.2
30	0.0	0.0	0.1	0.2	0.4	0.7	1.0	1.3	1.8	2.2	2.7
20	0.0	0.0	0.1	0.2	0.4	0.6	0.8	1.1	1.4	1.8	2.2
10	0.0	0.0	0.1	0.1	0.3	0.4	0.6	0.7	1.0	1.3	1.6
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Breaker Height (feet)

(Note: Surging breakers should only occur on beaches with steep gradients and should not occur with spilling breakers. See Figure 4-1)

Wave Angle Modification Table

Wave Angle (deg)											
40	0.0	0.1	0.3	0.7	1.3	2.0	2.9	3.9	5.1	6.5	8.0
35	0.0	0.1	0.3	0.6	1.1	1.8	2.5	3.4	4.5	5.7	7.0
30	0.0	0.1	0.2	0.5	1.0	1.5	2.2	2.9	3.8	4.9	6.0
25	0.0	0.1	0.2	0.5	0.8	1.3	1.8	2.5	3.2	4.1	5.0
20	0.0	0.0	0.2	0.4	0.6	1.0	1.4	2.0	2.6	3.2	4.0
15	0.0	0.0	0.1	0.3	0.5	0.8	1.1	1.5	1.9	2.4	3.0
10	0.0	0.0	0.1	0.2	0.3	0.5	0.7	1.0	1.3	1.6	2.0
5	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Breaker Height (feet)	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	≥ 5

Littoral Current Modification Table

Current (knots)	Modification
0.0	0.0
0.1	0.3
0.2	0.6
0.3	0.9
0.4	1.2
0.5	1.5
0.6	1.8
0.7	2.1
0.8	2.4
0.9	2.7
1.0	3.0
1.1	3.3
1.2	3.6
1.3	3.9
1.4	4.2
1.5	4.5
1.6	4.8
1.7	5.1
1.8	5.4
1.9	5.7
2.0	6.0
2.1	6.3
2.2	6.6
2.3	6.9
2.4	7.2
2.5	7.5
2.6	7.8
2.7	8.1
2.8	8.4
2.9	8.7
3.0	9.0

Wind Modification Tables

Wind Speed (knots)	Onshore			Offshore		
36-40	2.0	3.0	4.0	1.5	2.0	4.0
30-35	1.5	2.0	3.0	1.0	1.5	3.0
26-30	1.0	1.5	2.0	0.5	1.0	2.0
21-25	0.5	1.0	1.5	0.0	0.5	1.5
16-20	0.0	0.5	1.0	0.0	0.0	1.0
11-15	0.0	0.5	1.0	0.0	0.0	1.0
6-10	0.0	0.0	0.5	0.0	0.0	0.5
0- 5	0.0	0.0	0.0	0.0	0.0	0.0
Angle Relative to Beach (deg)	0-30	30-60	60-90	0-30	30-60	60-90

Appendix D

Sea State

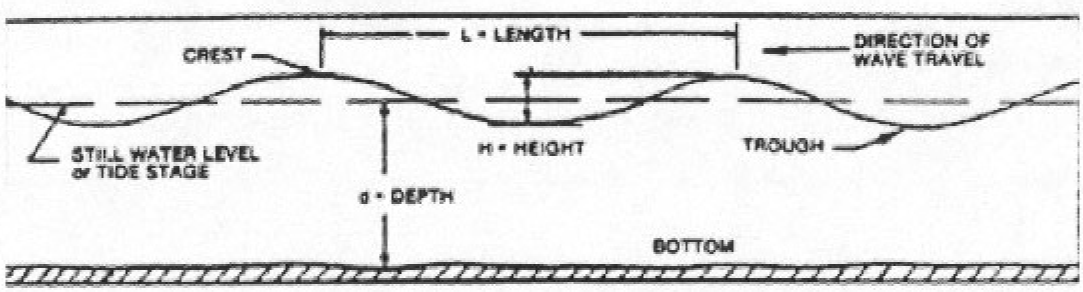
This Appendix presents information of the definition of Sea State, provides a working vocabulary, depictions of waves and breakers, and gives two examples of Sea State charts.

The main components of Sea State are the swell and waves. Swell is defined as long, often crestless waves which are products of far off weather conditions (such as a gale or storm). Waves are the smaller crested variety produced by local weather conditions.

Fetch: The area over which ocean waves are generated by wind having a constant direction and speed. Also known as the generating area.

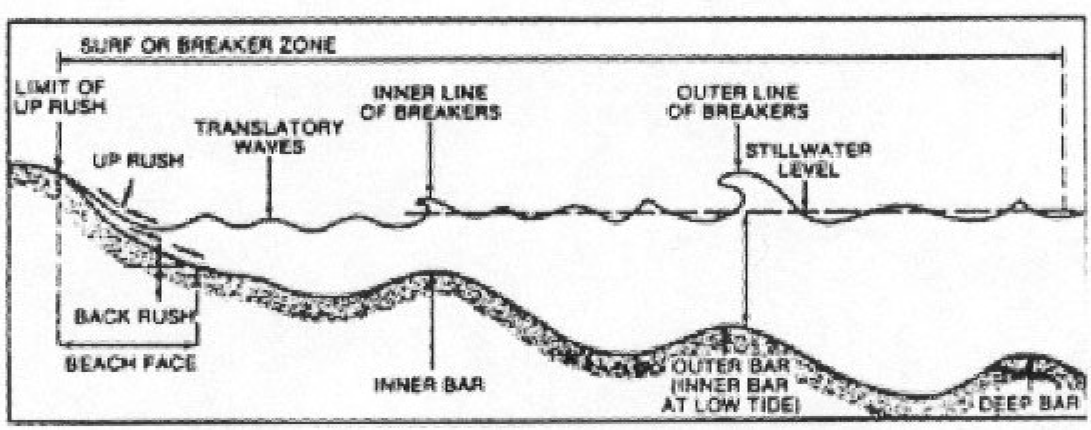
Sea: Waves generated or sustained by winds within their fetch opposed to swell.

Wave Height: The vertical distance between a wave trough and a wave crest.



DEFINITIONS OF WAVE CHARACTERISTICS

FIGURE 2-1



SCHEMATIC DIAGRAM OF WAVES IN THE BREAKER ZONE

FIGURE 2-2

Pierson-Moskowitz Sea Spectrum

- Values are worst case forecasts for open water in a particular location

Wind Speed (Kts)	Sea State	Significant Wave (Ft)	Significant Range of Periods (Sec)	Average Period (Sec)	Average Length of Waves (FT)
3	0	<.5	<.5 - 1	0.5	1.5
4	0	<.5	.5 - 1	1	2
5	1	0.5	1 – 2.5	1.5	9.5
7	1	1	1 – 3.5	2	13
8	1	1	1 - 4	2	16
9	2	1.5	1.5 - 4	2.5	20
10	2	2	1.5 - 5	3	26
11	2.5	2.5	1.5 - 5.5	3	33
13	2.5	3	2 - 6	3.5	39.5
14	3	3.5	2 – 6.5	3.5	46
15	3	4	2 - 7	4	52.5
16	3.5	4.5	2.5 - 7	4	59
17	3.5	5	2.5 - 7.5	4.5	65.5
18	4	6	2.5 - 8.5	5	79
19	4	7	3 - 9	5	92
20	4	7.5	3 – 9.5	5.5	99
21	5	8	3 – 10	5.5	105
22	5	9	3.5 – 10.5	6	118
23	5	10	3.5 - 11	6	131.5
25	5	12	4 – 12	7	157.5
27	6	14	4 – 13	7.5	184
29	6	16	4.5 – 13.5	8	210
31	6	18	4.5 – 14.5	8.5	236.5
33	6	20	5 – 15.5	9	262.5
37	7	25	5.5 - 17	10	328.5
40	7	30	6 – 19	11	394
43	7	35	6.5 - 21	12	460
46	7	40	7 – 22	12.5	525.5
49	8	45	7.5 - 23	13	591
52	8	50	7.5 - 24	14	566
54	8	55	8 – 25.5	14.5	722.5
57	8	60	8.5 – 26.5	15	788

Sea State Chart from U.S. Navy Diving Manual

Sea State	Description	Wind Force (Beaufort)	Wind Description	Wind Range (knots)	Wind Velocity (knots)	Average Wave Height (ft)
0	Sea like a mirror.	0	Calm	<1	0	0
	Ripples with the appearance of scales are formed, but without foam crests.	1	Light Air	5-3	2	0.05
1	Small wavelets still short but more pronounced; crests have a glassy appearance but do not break.	2	Light Breeze	4-6	5	0.18
2	Large wavelets, crests begin to break. Foam of glassy appearance, perhaps scattered whitecaps.	3	Gentle Breeze	7-10	8.5 10	0.6 0.88
3	Small waves, becoming longer; fairly frequent whitecaps.	4	Moderate Breeze	15-16	12 13.5 14 16	1.4 1.8 2.0 2.9
4	Moderate waves, taking a more pronounced long form; many whitecaps are formed. Chance of some spray.	5	Fresh Breeze	17-21	18 19 20	3.8 4.3 5.0
5	Large waves begin to form; white foam crests are more extensive everywhere. Some spray.	6	Strong Breeze	22-27	22 24 24.5 26	6.4 7.9 8.2 9.6
6	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind. Spindrift begins.	7	Moderate Gale	28-33	28 30 30.5 32	11 14 14 16
7	Moderately high waves of greater length; edges of crests break into spindrift. The foam is blown in well marked streaks along the direction of the wind. Spray affects visibility.	8	Fresh Gale	34-40	34 36 37 38 40	19 21 23 25 28
8	High waves. Dense streaks of foam along the direction of the wind. Sea begins to roll. Visibility affected.	9	Strong Gale	45-47	42 44 46	31 36 40
9	Very high waves with long overhanging crests. Foam is in great patches and is blown in dense white streaks along the direction of the wind. The surface of the sea takes on a white appearance. The rolling of the sea becomes heavy and shock-like. Visibility is affected.	10	Whole Gale	48-55	48 50 51.5 52 54	44 49 52 54 59
	Exceptionally high waves. The sea is completely covered with long white patches of foam along the direction of the wind. Everywhere the edges of the wave crests are blown into froth. Visibility seriously affected.	11	Storm	56-63	56 59.5	64 73
	Air filled with foam and spray. Sea completely white with driving spray. Visibility seriously affected.	12	Hurricane	64-71	>64	>80

Figure 6-7. Sea State Chart.

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